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Traffic Alert and Collision Avoidance System Signal Environmental Model (TCAS SEM) Programmer's Reference Manual

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16. Abstract

A Traffic Alert and Collision Avoidance System Signal Environment Model (TCAS SEM) was developed to predict the time-average TCAS I and minimum TCAS II signal rates in a user-selected air traffic deployment. This document describes the TCAS SEM. Included are descriptions of the modeled systems, the data-storage and retrieval subsystems for engineering data, and the software structures of all component subsystems.

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PREFACE

The Electromagnetic Compatibility Analysis Center (ECAC) is a Department of Defense facility, established to provide advice and assistance on electromagnetic compatibility matters to the Secretary of Defense, the Joint Chiefs of Staff, the military departments, and other DoD components. The Center, located at North Severn, Annapolis, Maryland 21402, is under policy control of the Assistant Secretary of Defense for Communication, Command, Control, and Intelligence and the Chairman, Joint Chiefs of Staff, or their designees, who jointly provide policy guidance, assign projects, and establish priorities. ECAC functions under the executive direction of the Secretary of the Air Force, and the management and technical direction of the Center are provided by military and civil service personnel. The technical support function is provided through an Air Force sponsored contract with the IIT Research Institute (IITRI).

This report was prepared for the Program Engineering and Maintenance Service of the Federal Aviation Administration in accordance with Interagency Agreement DOT-FA70WA1-175, as part of AF Project 649E under Contract F-19628-80-C-0042, by the staff of the IIT Research Institute at the Department of Defense Electromagnetic Compatibility Analysis Center.

To the extent possible, all abbreviations and symbols used in this report are taken from American Standards Y10.19 (1967) "Units Used in Electrical Science and Electrical Engineering" issued by the USA Standards Institute.

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SECTION 1

INTRODUCTION

1.1 BACKGROUND

During the past several years, the Electromagnetic Compatibility Analysis Center (ECAC) has supported the Federal Aviation Administration (FAA) by predicting the effects of various airborne Collision Avoidance Systems (CAS) on the existing FAA Air Traffic Control Radar Beacon System (ATCRBS) and the planned Mode S system.[1,2] In FY-81, ECAC investigated the effects of an omnidirectional version of the Traffic Alert and Collision Avoidance System (TCAS) on ATCRBS and Mode S system performance in a hypothetical Los Angeles Basin air traffic deployment and in subsets of that deployment.[3,4] For those air traffic deployments, it was predicted that TCAS activity would not degrade ATCRBS or Mode S ATC system performance; however, interference-limiting constraints resulted in undesired reductions in the protection volume of TCAS-equipped aircraft that were operating in densely populated airspace.

To maximize the protection area for TCAS-equipped aircraft operating in future high-density environments, the FAA proposed a new TCAS design. This design includes a directional, scanning antenna, improved Mode S tracking algorithms, a modified whisper-shout sequence (to maintain surveillance of

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[1]Theberge, Norman, The Impact of a Proposed Active BCAS on ATCRBS Performance in the Washington, DC, 1981 Environment, FAA-RD-177-140, FAA, Washington, DC, September 1977, ADA 048589.

[2]Gettier, C. et al., Analysis of Elements of Three Airborne Beacon Based Collision Avoidance Systems, FAA-RD-79-123, FAA, Washington, DC, May 1979, ADA 082026.

[3]Hildenberger, Mark, User's Manual for the Los Angeles Basin Standard Traffic Model Card Deck/Character Tape Version, FAA-RD-73-89, FAA, Washington, DC, May 1973, ADA 768846.

[4]Patrick, G. and Keech, T., Impact of an Omnidirectional Traffic Alert and Collision Avoidance System on the Air Traffic Control Radar Beacon System and the Discrete Address Beacon System, FAA/RD-81/106, FAA, Washington, DC, November 1981, ADA 116170.

ATCRBS-equipped aircraft), and associated revisions to the interference limiting algorithm.[5] The design was chosen to reduce the extent of interference limiting and thus allow TCAS-equipped aircraft to successfully perform the collision avoidance function in even the most congested airspace and also to reduce the potential for interference with ground-based ATC systems.

Three versions of TCAS have been proposed: Enhanced TCAS II, Minimum TCAS II (TCAS II M), and TCAS I. Enhanced TCAS is still in the design phase, and as such, is not addressed in this study. TCAS II M is capable of omnidirectional Mode S surveillance and limited directional ATCRBS surveillance. TCAS II M-equipped aircraft track nearby ATCRBS transponder-equipped aircraft by periodically eliciting replies using an ATCRBS-only interrogation format; nearby Mode S transponder-equipped aircraft are tracked by periodically eliciting replies using a Mode S interrogation format. The TCAS II M is designed for use in commercial aircraft. TCAS I, a less expensive version of TCAS, locates nearby aircraft, both ATCRBS- and Mode S-equipped, by periodically eliciting replies using an ATCRBS interrogation format. The TCAS I is designed for use in general aviation aircraft.

To investigate the effects of TCAS I and TCAS II M operations on ATCRBS and Mode S ATC performance, ECAC was requested to perform a simulation analysis, similar to the FY-81 Los Angeles Basin study. This analysis was performed using the TCAS Signal Environment Model (SEM).[6] This model is used to predict the time-average rates at which TCAS signals are received at ATC transponders in a given deployment. These rates are then used in the

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[5]Radio Technical Commission for Aeronautics, Minimum Operational Performance Standards (MOPS) for Traffic Alert and Collision Avoidance System (TCAS) Airborne Equipment, RTCA/DO-185, Washington, DC, September 1983.

[6]Patrick, G. et al., The Impact of a Traffic Alert and Collision Avoidance System on the Air Traffic Control Radar Beacon System and Mode S System in the Los Angeles Basin, DOT/FAA/PM-84/30, FAA, Washington, DC, May 1985.

DABS/ATCRBS/AIMS[a] Performance Prediction Model (PPM)[7] to merge the TCAS signal environment with signals due to ground-based ATC systems. The DABS/ATCRBS/AIMS PPM then predicts the performance of a selected interrogator-of-interest in the composite ATC and TCAS signal environment.

This document describes the TCAS SEM. Included are descriptions of the modeled systems, the data-storage and retrieval subsystems for engineering data, and the software structures of all component subsystems. The results of the FY83/84 TCAS SEM simulation exercise using Los Angeles Basin air traffic deployments are presented in the document cited in Reference 6.

1.2 OBJECTIVE

The objective of this effort was to document the TCAS Signal Environment Model (SEM) that was developed to predict time-averaged TCAS I and TCAS II M signal rates in a given air traffic deployment.

1.3 APPROACH

1.3.1 Design Rationale

The TCAS SEM was developed to be used in conjunction with the DABS/ATCRBS/AIMS PPM to predict the performance of ATCRBS and Mode S ATC systems in an environment including both TCAS and ATC system surveillance activity. The TCAS SEM simulates TCAS surveillance operation and predicts the time-averaged rates at which TCAS signals are received at all environmental ATC transponders. These rates are then accessed by the DABS/ATCRBS/AIMS PPM during a simulation exercise, and merged statistically, using Monte Carlo techniques, with the deterministically produced signal environment associated

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[a] The Discrete Address Beacon System (DABS) was renamed Mode S after the completion of the DABS/ATCRBS/AIMS PPM.

[7] Crawford, C. R. and Ehler, C. W., The DABS/ATCRBS/AIMS Performance Prediction Model, FAA-RD-79-88, FAA, Washington, DC, November 1979, ADA 089440.

with ground-based ATC and surveillance operations. The DABS/ATCRBS/AIMS PPM then predicts the performance of a user-selected interrogator-of-interest (I_O) in the composite ATC and TCAS signal environment.

This method of statistically merging the TCAS signal environment with the ATC environment is permissible since the time variations in TCAS signal activity are relatively small in comparison to variations in ground-based ATC signal activity. Specifically, ground-based ATC systems employ highly directional scanning antennas; consequently, there are periods when an aircraft is not within the mainbeam of a single interrogator, and periods when the same aircraft is simultaneously with the mainbeams of several interrogators. This phenomenon leads to large scan-to-scan signal rate variations.

The TCAS I and TCAS II M do not produce large time variations in signal activity. The proposed low power, active TCAS I transmits one ATCRBS interrogation/sequence per second on an omnidirectional antenna.[8] To simplify the analysis, TCAS I is modeled in the TCAS SEM as transmitting one interrogation per second. TCAS II M transmits the ATCRBS interrogation sequence once per second on a wide-beam (BW < 130°) antenna which is electronically steered to four positions (forward, left-side, right-side, and aft). TCAS II M transmits Mode S interrogations on an omnidirectional antenna. The Mode S interrogation rate transmitted by a given TCAS II M-equipped aircraft is a function of the number of Mode S-equipped aircraft within approximately thirty nautical miles. Since the changes in air-traffic density throughout the LA Basin deployment have been shown to be negligible during the 10-scan (46 seconds) DABS/ATCRBS/AIMS simulation, TCAS rates are relatively constant. In view of these considerations, the compatibility of TCAS I and TCAS II M with ATCRBS and Mode S can logically be analyzed using this statistical approach.

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[8]Welch, J. D. and Harman, W. H., Improved TCAS I for Pilot Warning Indication, AIAA/IEEE 6th Digital Avionics System Conference, December 1984, pp. 593-596.

1.3.2 Simulation Execution

The execution sequence for the two models is illustrated in Figure 1-1. The user first executes a 10-scan DABS/ATCRBS/AIMS PPM simulation to estimate the time-average rates at which ATC interrogations and suppressions arrive at each aircraft within a given deployment. These rates are then used within the TCAS SEM to estimate the mean reply efficiency and reply rate of each transponder. The TCAS SEM uses the transponder reply efficiency and reply rate to estimate TCAS II M Mode S surveillance activity. This is accomplished as follows. The TCAS II M surveillance protocol requires that a TCAS II M-equipped aircraft elicit a decodable Mode S reply once per second from all other Mode S-equipped aircraft within approximately 7 nmi, and at a rate which decreases monotonically with range for aircraft beyond 7 nmi. The efficiency with which a TCAS II M elicits decodable replies is related to the local fruit rate, which is a function of the local air traffic density and the local transponder reply rate. The number of interrogations required by a given TCAS II M to elicit a decodable reply therefore increases with increases in the local fruit rate.

This background signal environment must therefore be specified in order to accurately predict TCAS II M Mode S surveillance rates. With these input parameters, the TCAS SEM is exercised to simulate two minutes of real time[a] to predict the time-averaged rates at which TCAS I and TCAS II M signals arrive at each transponder. The DABS/ATCRBS/AIMS PPM uses these TCAS signal rates as a basis with which to merge TCAS signals with those due to ground-based ATC systems.

1.3.3 Report Organization

The remainder of this report is divided into two sections and three appendixes. The modeled TCAS and ATC transponder systems are discussed in Section 2. Section 3 contains a tree diagram of the program control flow

[a]This is a sufficient time to allow any model-induced transients to decay.

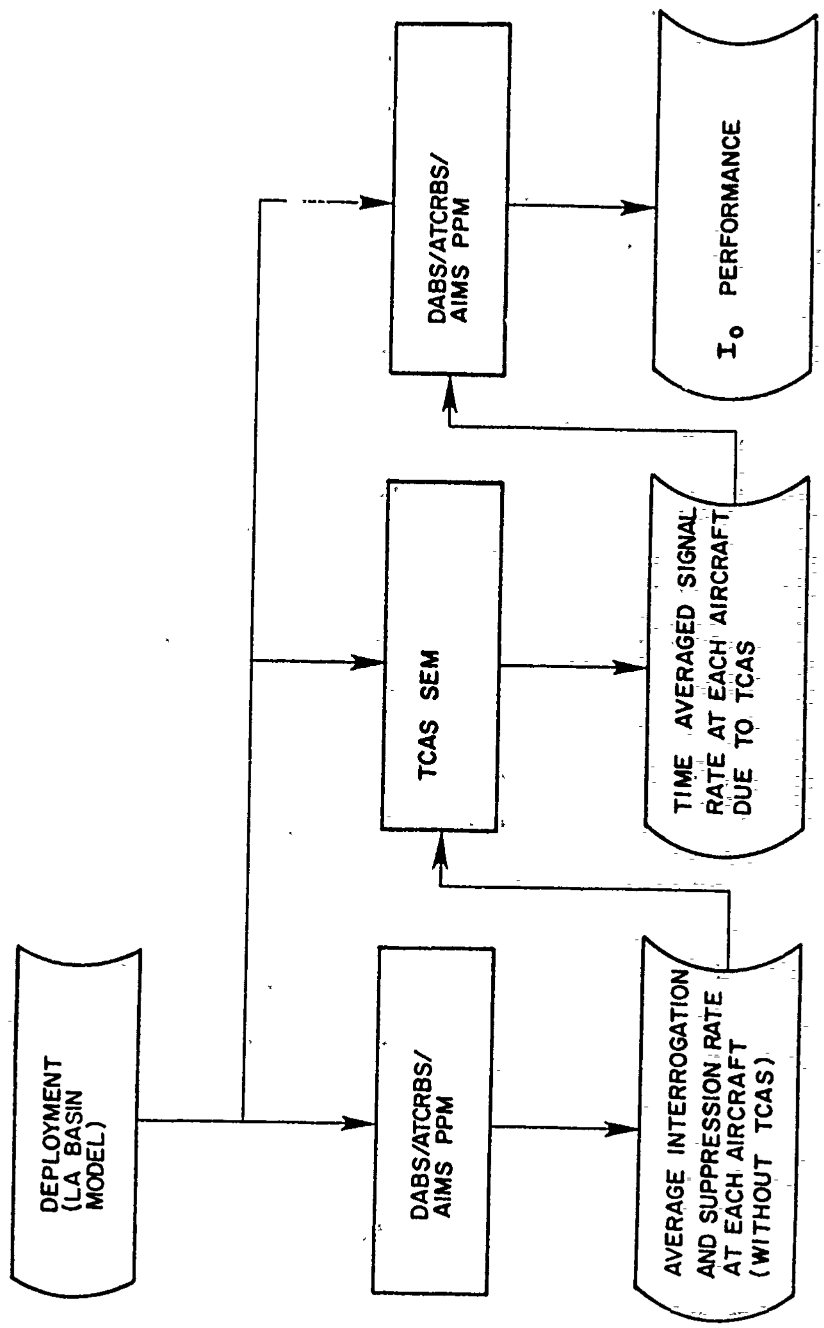

Figure 1-1. Analysis structure.

and detailed descriptions in Program Design Language (PDL) of each subroutine in the model. The PDL replaces the flow-chart method of documenting software and gives a more detailed and accurate description of the code. A PDL was written for the driver and each subroutine in the TCAS SEM, and each includes the following elements: Purpose, Inputs, Procedure, Outputs, Variables of Interest, and Process. The first four elements of the PDL contain general information about the program segment: its function, its inputs, the procedure by which it achieves its function, and its outputs. The last two elements contain specific information about the code and were provided to ease understanding and modification of the code by the programmer. Specifically included are a definition of the variables used in the program segment and pseudo-code that explains the coded listing in a nearly line-by-line fashion.

APPENDIX A contains a data dictionary containing all the common variables in the model. APPENDIX B lists a fully commented ASCII FORTRAN version of the model, and APPENDIX C illustrates the procedure for executing the model and a sample of its output.

SECTION 2

MODELED SYSTEMS

2.1 INTRODUCTION

This section contains a brief description of the technical characteristics and surveillance procedures, as modeled, of TCAS I and TCAS II M. This is followed by a description of the modeled ATC transponder systems.

2.2 TCAS OPERATIONS AND TECHNICAL CHARACTERISTICS

2.2.1 TCAS II M

TCAS II M is an airborne system that is designed to use existing ATCRBS and Mode S signal formats to perform the collision-avoidance function. TCAS II M tracks ATCRBS-equipped aircraft in its vicinity via the whisper-shout power management technique. Nearby Mode S-equipped aircraft are tracked via discrete Mode S transactions. The ATCRBS whisper-shout surveillance sequence is transmitted once per second. The Mode S transaction update frequency is related to the position of the Mode S equipped aircraft relative to the position of the TCAS II M. Mode S and ATCRBS surveillance procedures are discussed in detail below. TCAS II M characteristics are given in TABLE 2-1.

2.2.1.1 Mode S Surveillance Process. Initially, each Mode S aircraft is assumed to be in the null state. Upon detection of a squitter, the aircraft is placed in the squitter state. If a second squitter is received within 16 seconds of the first, the aircraft is placed in the acquisition state, unless the altitude separation is greater than 9000 feet, in which case the intruder aircraft remains in the squitter state. A target aircraft is purged from squitter processing if a second squitter reply is not received within 16 seconds of the first reply. These replies may be either replies elicited by another TCAS II M-equipped aircraft or unelicited replies.

TABLE 2-1

TCAS II M CHARACTERISTICS

Charcteristic	Mode S		ATCRBS	
	Mean	Standard Deviation	Mean	Standard Deviation
Peak Radiated Power[a]	54 dBm	0.5	49 dBm	0.5
Sensitivity[a]	-77 dBm	0.75	-74 dBm	0.75
Antenna Type[9]	Omnidirectional		Directional (130°)[b]	

[a]Transmitter power and sensitivities were assigned using a normal distribution.

[b]At sum-difference crossover points.

While the aircraft is in the acquisition state, TCAS II M interrogates to determine if the aircraft should be placed in the roll-call or dormancy state. The number of interrogations transmitted during acquisition is a function of the TCAS II M ability to receive and correlate replies from the intruder Mode S aircraft. There are four acquisition trials, each consisting of six one-second scans. TABLE 2-2 shows the maximum number of failed interrogations allowed during each of the four trials. For example, during the first scan of the first trial, TCAS II M may transmit as many as four interrogations (one successful, three unsuccessful).

If two correlating replies are received during any trial sequence, the intruder aircraft is placed either in the dormancy state or in the roll-call state. The aircraft is placed in the dormancy state if TCAS II M estimates the "Time to Endanger" (TE = range/maximum closure rate) to be greater than 43 seconds; otherwise, the intruder is placed in the roll-call state.

If no replies are received during any one of the trials, the intruder aircraft is returned to the squitter state for a period not to exceed 40

[9]Lee, J., Data Package for TCAS-II Antenna, R-3761-10266, Dalmo Victor Company, 29 March 1982, (Proprietary Data).

TABLE 2-2

MAXIMUM NUMBER OF FAILED INTERROGATIONS ALLOWED DURING EACH SCAN OF THE ACQUISITION TRIALS

Scan	Acquisition Trial			
	1	2	3	4
1	3	2	1	1
2	3	2	1	0
3	3	2	1	0
4	0	0	0	0
5	0	0	0	0
6	0	0	0	0

seconds. Upon the return of intruder aircraft to squitter state, a running sum, initialized at 0, is maintained. The sum is decremented by one for each succeeding scan that a squitter is not received and is incremented by an amount as shown in TABLE 2-3 for each scan that a squitter is received. The intruder is purged from the squitter state and placed into the null state when the value of the running sum becomes less than or equal to -40. It is transferred to the acquisition state whenever the running sum exceeds 0 unless the altitude separation is greater than 9000 feet.

TABLE 2-3

INCREMENTS BY SCAN TO SQUITTER SUM FOR CLEAR RECEPTION OF SQUITTER

Scan	0	1	2	3	4 (or more)
Increment	20	16	8	4	2

Aircraft assigned to the dormancy state are not interrogated. The aircraft remains in the dormancy state for a period of time equal to TE minus 40 seconds. After this time, the aircraft is placed in the squitter state.

If the aircraft is assigned to the roll-call state (i.e., the TE is less than 43 seconds), TCAS II M interrogates the intruder each second to update its track record. TABLE 2-4 shows the maximum number of interrogations permitted to elicit a decodable reply during each one-second scan. This is referred to as the ten-second roll-call sequence. If the entire ten-scan sequence elapses with no valid reply, interrogations to the intruder aircraft are terminated, and the aircraft is returned to the squitter state.

TABLE 2-4

MAXIMUM INTERROGATIONS ALLOWED DURING EACH ROLL-CALL SCAN TO ELICIT A DECODABLE REPLY

Scan	Maximum Number of Interrogations
1	5
2	4
3	3
4	2
5	2
6	2
7	2
8	2
9	2
10	2

2.2.1.2 Whisper-shout ATCRBS surveillance. The current TCAS II M design employs a four-beam directional antenna on top of the aircraft and an omnidirectional antenna on the bottom of the aircraft. Each TCAS II M-equipped aircraft tracks ATCRBS-equipped aircraft via the whisper-shout power management technique shown in Figure 2-1.

This technique uses directional interrogations from each of the four beams of the top antenna. The interrogation sequence starts with a lower power interrogation level (26 dBm) and proceeds to higher power interrogation levels in 1-dB increments. A total of 83 whisper-shout interrogations are transmitted each second unless interference limiting adjustments are required. Interrogations are eliminated from the sequence in the order shown

		TOTAL RADIATED INTERROGATION POWER (dBm)	INTERFERENCE LIMITING PRIORITY
TOP ANTENNA	S..I	49	1
	S.I	48	5
	S..I	47	9
FORWARD DIRECTION	S.I	46	13
	S..I	45	17
	S.I	44	21
	S..I	43	25
	S.I	42	29
	S..I	41	33
	S.I	40	37
	S..I	39	41
	S.I	38	45
	S..I	37	49
	S.I	36	53
	S..I	35	57
	S.I	34	61
	S..I	33	64
	S.I	32	67
	S..I	31	70
	S.I	30	73
	S..I	29	76
	S.I	28	77
	S..I	27	78
	...I	26	79
TOP ANTENNA	S..I	45	2,3
	S.I	44	6,7
	S..I	43	10,11
LEFT & RIGHT DIRECTIONS	S.I	42	14,15
	S..I	41	18,19
	S.I	40	22,23
	S..I	39	26,27
	S.I	38	30,31
	S..I	37	34,35
	S.I	36	38,39
	S..I	35	42,43
	S.I	34	46,47
	S..I	33	50,51
	S.I	32	54,55
	S..I	31	58,59
	S.I	30	62,63
	S..I	29	65,66
	S.I	28	68,69
	S..I	27	71,72
	...I	26	74,75

24 34 44 54
RADIATED POWER (dBm)

Figure 2-1. Whisper-shout interrogation sequence. (Page 1 of 2).

		TOTAL RADIATED INTERROGATION POWER (dBm)	INTERFERENCE LIMITING PRIORITY
S.I		40	4
S..I		39	8
S.I		38	12
S..I	TOP	37	16
S.I	ANTENNA	36	20
S..I		35	24
S.I	AFT	34	28
S..I	DIRECTION	33	32
S.I		32	36
S..I		31	40
S.I		30	44
S..		29	48
S.I		28	52
S..I		27	56
..I		26	60
S..I		36	80
S..I	BOTTOM OMNI	34	81
S..I	ANTENNA	32	82
......I		30	83

24 34 44 54

RADIATED POWER (dBm)

Notes: "I" indicates total radiated power of P_1, P_3, and P_4 interrogation pulses.

"S" indicates total radiated power of P_1 and P_2 suppression pulses.

"S.I" means that the total radiated suppression power is 2 dB less than the total radiated interrogation power.

"S..I" means that the total radiated suppression power is 3 dB less than the total radiated interrogation power.

Figure 2-1. (Page 2 of 2).

in Figure 2-1 if interference limiting adjustments are required. The interference limiting procedures are discussed in subsection 2.2.3.

Each successive interrogation in the sequence is preceded by a suppression. This suppression is used to prevent the more sensitive transponders from replying again. The suppression pulse is at a power level 2 or 3 dB lower than the accompanying interrogation. Partitioning the ATCRBS environment with respect to transponder sensitivity reduces the number of overlapping replies received by the TCAS II M receiver. The function of the transmission from the bottom antenna is to minimize false targets that are generated by multipath conditions.

2.2.2 TCAS I

TCAS I is a lower-cost, limited-performance version of TCAS that is compatible with TCAS II M operation. Its main functions are 1) to support surveillance for TCAS II M as well as ground air traffic control and (2) to maintain surveillance of nearby transponder-equipped aircraft. To support the surveillance function, TCAS I interrogates once per second using an ATCRBS Mode C format.[10] The interrogation is transmitted on an omnidirectional antenna. The transmission power and interference limiting standards for TCAS I have been proposed but have not been formally adopted (see Reference 8).

2.2.3 TCAS/ATC Compatibility Design

Each TCAS II M unit incorporates interference limiting to ensure that TCAS II M signals will not interfere with other systems when operating in high-density airspace. TCAS II M controls its interrogation rate and/or power to minimize interference effects by conforming to a set of three specific inequalities. This ensures that all interference effects resulting from these

[10] Traffic Alert and Collision Avoidance System (TCAS I) Design Guidelines, FAA-RD-82-12, FAA, Washington, DC, April 1982.

interrogations, together with the interrogations from all other TCAS II M airborne interrogators in the vicinity, are kept to a low level. The number of Mode S and ATCRBS interrogations made by a TCAS II M-equipped aircraft and the number of other TCAS II M-equipped aircraft within squitter range are computed. These computed quantities are used in the following three interference-limiting equations:

$$\sum_{i=1}^{I} \frac{P(i)}{250 \text{ watts}} \leq \frac{280}{1 + NTA} \qquad (2\text{-}1)$$

$$\sum_{i=1}^{I} M(i) \leq 0.01 \text{ second} \qquad (2\text{-}2)$$

$$\sum_{k=1}^{K} \frac{PA(k)}{250 \text{ watts}} \leq \frac{80}{1 + NTA} \qquad (2\text{-}3)$$

The variables in these inequalities are defined as follows:

- I = the total number of Mode S interrogations transmitted in a 1-second period.
- i = the index number of the current Mode S interrogation; i = 1, 2, ..., I.
- P(i) = the total radiated Mode S power (in watts) from the antenna for the i-th interrogation.
- NTA = the number of airborne TCAS II M interrogators that are detected by squitter.
- M(i) = the duration of the mutual suppression interval for the TCAS II M transponder associated with the i-th interrogation.
- K = the total number of ATCRBS interrogations in a 1-second period.
- k = the index number of the ATCRBS interrogation;

$k = 1, 2, \ldots, K.$

PA(k) = the total radiated power (in watts) from the antenna for the k-th ATCRBS interrogation.

The TCAS II M unit will determine once per second if the power and/or interrogation rate should be adjusted. Each TCAS II M varies the system parameters computed in inequalities (2-1), (2-2), and (2-3) to maximize the surveillance ranges for Mode S and ATCRBS aircraft, while limiting the total power and interrogation rate not to exceed set values.

At the beginning of each surveillance update interval (each second), the number of TCAS II M interrogators detected by squitter is used to evaluate the current right-hand limits in inequalities (2-1) and (2-3). The average values over a 16-second interval for the Mode S variables in the inequalities are also calculated. If the average value of the left-hand side of either inequality (2-1) or (2-2) equals or exceeds the current limit, both the Mode S and the ATCRBS surveillance parameters are modified to satisfy the inequalities.

The ATCRBS surveillance activity is modified by sequentially eliminating elements of the whisper-shout sequence. Each whisper-shout step is uniquely associated with a TCAS II M receiver Minimum Triggering Level (MTL) setting. Thus, the receiver sensitivity in ATCRBS surveillance periods is automatically tailored to match these power reductions.

Mode S surveillance activity is modified by adjusting Mode S interrogation power and/or squitter sensitivity. In evaluating these inequalities, 16-second averages of the Mode S parameters and current or anticipated values of the ATCRBS parameters are used. After the Mode S variables (power and/or squitter sensitivity) have been changed to satisfy the inequalities during the update interval, the only change allowed during the next 16 seconds is a reduction in the number of whisper-shout steps needed to satisfy inequality (2-3). This is designated the 16-second freeze.

2.3 ATC TRANSPONDER CHARACTERISTICS

Each transponder-equipped aircraft is represented by an antenna (omnidirectional in azimuth), antenna cable, receiver/processor, and a transmitter. The (quantized) vertical antenna gain patterns were derived from measured data for the Boeing 727 antenna/airframe configuration.[a] For modeling purposes, it is assumed that ATCRBS transponder-equipped aircraft are fitted with a single, bottom-mounted antenna, while Mode S transponder-equipped aircraft are fitted with both top- and bottom-mounted antennas. Polarization losses are neglected. The cable loss from the antenna terminals to the receiver/transmitter terminals is assumed to be 3 dB for the entire transponder population.

The receiver sensitivity and transmitter power output of each type of transponder are assigned statistically in accordance with measured data.[11] For ATCRBS transponders, the values of receiver sensitivity range between -51 dBm and -90 dBm, with an average value of -74 dBm; the values of transmitter power range between 46 dBm and 65 dBm, with an average power of 57 dBm.

Mode S transponder-equipped aircraft receiver/transmitter characteristics are assigned using a normal probability distribution function. The receiver sensitivity distribution for Mode S transponder-equipped aircraft that are not TCAS II M-equipped are assigned using a mean value of -77 dBm with a standard deviation of 1.5 dB. The sensitivity distribution for Mode S transponder-equipped aircraft that are TCAS II M-equipped is constructed using a mean value of -77 dBm with a standard deviation of 0.5 dB. Reply power levels for the two populations of Mode S transponders are assigned in a similar way: an average reply power of 57 dBm for both populations with standard deviations of 1.5 dB for Mode S aircraft that are not TCAS II M-equipped, and 0.5 dB for

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[a]Patterns were supplied to ECAC by the FAA.

[11]Colby, G. V. and Crocker, E. A., Final Report Transponder Test Program, FAA-RD-72-30, FAA, Washington, DC, April 1972.

Mode S aircraft that are TCAS II M-equipped.

Transponders are subjected to a variety of signal formats from ATCRBS interrogators, Mode S interrogators, and TCAS interrogators. The reaction of a transponder receiver/processor and transmitter to each type of signal is, in general, different for Mode S and ATCRBS transponders. TABLE 2-5 lists the different types of signals that may be received at transponders, and the attendant receiver/processor and transmitter action.

TABLE 2-5

TRANSPONDER INTERROGATION PROCESSING AND DEAD TIMES

Transmission Type	Transponder Type	Receiver Dead Time (μs)	Transmitter Action
ATCRBS Interrogation	ATCRBS	60	Reply
ATCRBS-Only Interrogation[a]	ATCRBS	60	Reply
ATCRBS-Suppression	ATCRBS	35	Suppression
Mode S Interrogation (All-Call and Roll-Call)	ATCRBS	35	Suppression
ATCRBS Interrogation	Mode S	60	Reply
ATCRBS-Only Interrogation	Mode S	24	Suppression
ATCRBS Suppression	Mode S	35	Suppression
Mode S Interrogation	Mode S	192 (short reply)	Reply
		248 (long reply)	Reply
Mode S Interrogation (not at transponder address)	Mode S	20 (short interrogation)	Suppression
		32 (long interrogation)	Suppression
Mode S All-Call Interrogation	Mode S	128	Reply[b]

[a]ATCRBS-only interrogations are transmitted by Mode S sensors and TCAS II M interrogators.

[b]The probability of reply of Mode S transponders to Mode S All-Call Interrogation is controlled by data contained in the interrogation.

SECTION 3
MODEL DESCRIPTION

3.1 INTRODUCTION

The TCAS SEM is divided into a main driver program and 24 separate subroutines, each of which performs a specific function. Figure 3-1 shows the major functions of the model and identifies the subroutines that perform those functions. To the left of each subroutine shown on the diagram is a general description of the function(s) that it performs. The information contained in this section is presented in the form of PDLs (program design language) to be used in conjunction with the actual code of the TCAS SEM (APPENDIX B). The PDLs provide a detailed description of the variables and the logic of each subroutine.

3.2 OPERATIONAL DESCRIPTION

The DABS/ATCRBS/AIMS PPM and the TCAS SEM were designed in ASCII FORTRAN for use on the ECAC Sperry 1100/82 computer. The TCAS SEM is machine-dependent because of its use of system subroutines and system functions.

3.2.1 Input/Output Files

The DABS/ATCRBS/AIMS PPM creates an input disk file (See TABLE 3-1) for the TCAS SEM that contains average interrogation and suppression rates due to ground air traffic control for each aircraft in the deployment. The aircraft's position (latitude, longitude, and altitude), type (ATCRBS, Mode S, or TCAS II M), and its velocity (East-West, North-South, and vertical directions) are supplied by the LA Basin Model (Reference 3) using the format of TABLE 3-2. Using this information, the TCAS SEM simulates TCAS activity during a 120-second interval. At the end of the simulation, the TCAS SEM creates a disk file which includes the time-average rates at which TCAS signals arrive at each aircraft. The types of signal rates stored are listed in TABLE 3-3.

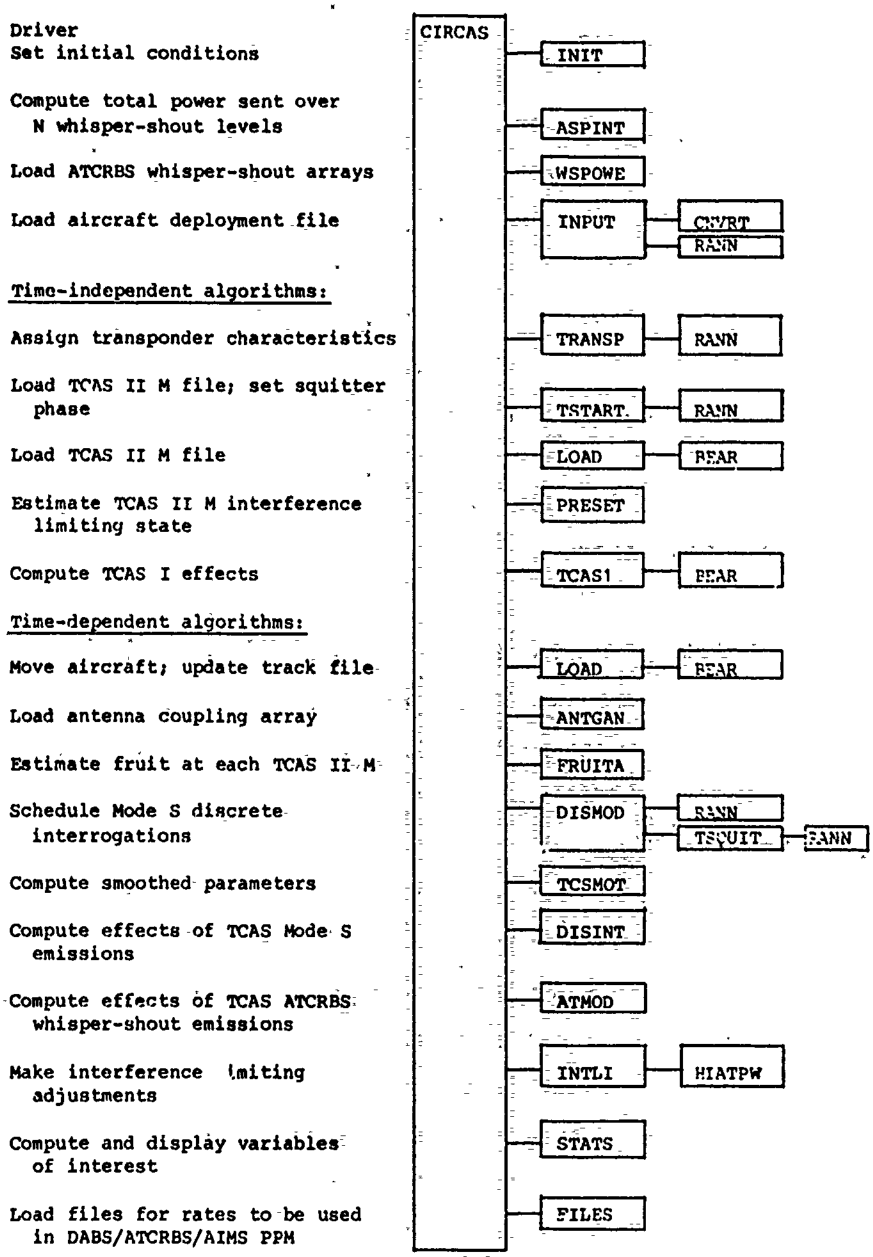

Figure 3-1. Tree diagram of the TCAS SEM.

TABLE 3-1

FORMAT OF INPUT FILE TO TCAS SEM FORMED BY DABS/ATCRBS/AIMS PPM

Beginning Column	Length	Format	Quantity
11	10	I10	Interrogation Rate due to ground ATC (per second)
21	10	I10	Suppression Rate due to ground ATC (per second)

TABLE 3-2

FORMAT OF DEPLOYMENT FILE

Beginning Column	Length	Format	Quantity
1	2	I2	Latitude (Degrees)
3	2	I2	Latitude (Minutes)
5	2	I2	Latitude (Seconds)
7	1	A1	Hemisphere (N-S)
8	3	I3	Longitude (Degrees)
11	2	I2	Longitude (Minutes)
13	2	I2	Longitude (Seconds)
15	1	A1	Hemisphere (E-W)
19	8	F8.0	Altitude (feet msl)
36	4	A4	Type
41	6	F6.4	Westward Velocity (nmi/s)
48	6	F6.4	Northward Velocity (nmi/s)
55	8	F8.4	Upward Velocity (ft/s)

TABLE 3-3

FORMAT OF OUTPUT FILE GENERATED BY TCAS SIM TO BE USED AS INPUT TO DABS/ATCRBS/AIMS PPM

Beginning Column	Length	Format	Quantity
11	15	I15	Mode S Misaddresses due to TCAS II M
26	15	I15	Mode S Suppressions due to TCAS II M
41	15	I15	Mode S Interrogations due to TCAS II M
56	15	I15	ATCRBS Interrogations due to TCAS II M
71	15	I15	ATCRBS Suppressions due to TCAS II M
86	10	F10.5	Mode S Addresses due to TCAS II M
98	10	F10.3	TCAS II M dead time
110	10	F10.3	TCAS I Interrogations to aircraft

3.2.2 Internal Data Structure

In order to connect each segment of the TCAS SEM, common blocks of data were designated to share information. The data dictionary in APPENDIX A describes each common variable and its units.

3.3 MODEL SUBROUTINE DESCRIPTIONS

The subroutines of the model are described in PDL form in this section, in the order in which they appear on the tree diagram of Figure 3-1. The PDLs are divided into Purpose, Inputs, Procedure, Outputs, Variables of Interest, and Process. This method of documentation provides a detailed description of each subroutine in a form that can be easily updated as modifications are made to the model.

3.3.1 Model Driver: CIRCAS

PURPOSE: To drive the TCAS SEM:

1. Set initial conditions and load aircraft files.
2. Calculate near time-independent effects of TCAS I (if desired) and TCAS II M emissions.
3. Calculate time-dependent effects of TCAS II M on the environment.
4. Record the results of the TCAS SEM on disk files to be used in the DABS/ATCRBS/AIMS PPM.

INPUTS: ATC files from DABS/ATCRBS/AIMS PPM, and transponder deployment information.

PROCEDURE: First, all the subroutines that set up the initial conditions of the simulation (e.g., whisper-shout power levels, number of aircraft in the deployment, etc.) are called. Next, a simulation of 120 seconds of the operation of the TCAS II M system is performed. During the simulation, the Mode S and ATCRBS interrogation and suppression rates due to TCAS II M interrogations is computed for all aircraft in the environment, along with the mutual suppression rate of each TCAS II M receiver. At the end of the simulation, the average value of Mode S and ATCRBS rates are computed and stored in external files to be used in conjunction with the DABS/ATCRBS/AIMS PPM.

OUTPUTS: ATC files for use in DABS/ATCRBS/AIMS PPM.

VARIABLES OF INTEREST

Description	Variable Name
Number of TCAS II M-equipped aircraft	NUMTCA
Clock	ITIME
TCAS II M-equipped aircraft of interest	II
TCAS II M transmission indicator	LPLUS1
Print indicator	PRINT
TCAS I analysis indicator	T1

PROCESS:

1. Read in user's options (print option and TCAS I analysis option).
2. CALL INIT: Set initial conditions of all common block variables.
3. CALL ASPINT: Initialize array containing total whisper-shout power radiated.
4. CALL WSPOWE: Load whisper-shout power levels for TCAS II M-equipped aircraft.
5. CALL INPUT: Load aircraft deployment from the transponder deployment file (usually the LA Basin Model) and interrogation and suppression rates from the DABS/ATCRBS/AIMS PPM.
6. CALL TRANSP: Assign power and sensitivity for each transponder.
7. CALL TSTART: Set squitter phase for each TCAS II M-equipped aircraft and a pointer file to locate TCAS II M-equipped aircraft in the aircraft characteristics file.
8. CALL LOAD: Compute heading of each TCAS II M; update MODE S track file (i.e., load array containing power, range, and bearing relationships between TCAS II M-equipped and all other aircraft within 50 nmi); and compute the air traffic densities about each TCAS II M, as well as the average density about all TCAS II M-equipped aircraft.
9. CALL PRESET: Approximate interference-limiting effects on each TCAS II M-equipped aircraft.
10. **IF** TCAS I analysis desired, **THEN**
    A. CALL TCAS1: Determine signal rates due to TCAS I ATCRBS surveillance.
11. **END IF**
12. **LOOP** over 120-second time interval, in one-second steps.
    A. CALL LOAD: At times 40, 80, and 120 seconds: update all aircraft positions; update MODE S track file and compute the air traffic densities about each TCAS II M-equipped, as well as the average density about any given TCAS II M-equipped aircraft.
    B. **LOOP** over all TCAS II M-equipped aircraft.
        1. CALL ANTGAN: Compute antenna elevation patterns between given TCAS II M-equipped aircraft and all other aircraft within 50 nmi of the TCAS II M.

2. **IF** time equals 1, 20, 40, 60, 80, 100, or 120 seconds, **THEN**
   a. CALL FRUITA: Compute the reply efficiency of each aircraft to the TCAS II M-equipped aircraft and the associated fruit rate to that efficiency.
3. **END IF**
4. CALL DISMOD: Schedule Mode S discrete interrogations.
5. CALL TCSMOT: Compute smooth (or average) TCAS II M emission powers and interrogation rates over the last 16-second interval.
6. **IF** TCAS II M transmitted Mode S interrogations **THEN**
   a. CALL DISINT: Compute Mode S effects from TCAS II M to all other aircraft in range of the TCAS II M.
7. **END IF**
8. **IF** time equals 1, 40, 80, or 120 seconds, **THEN**
   a. CALL ATMOD: Compute whisper-shout effects of TCAS II M on all other aircraft within range.
9. **END IF**
10. **IF** time is greater than three seconds, **THEN**
    a. CALL INTLI: Adjust TCAS II M characteristics to satisfy interference-limiting inequalities.
11. **END IF**
12. CALL STATS: Compute average rates from all TCAS II M-equipped aircraft to all other aircraft.

C. **END LOOP**

13. **END LOOP**
14. CALL FILES: Load rate files for use in the DABS/ATCRBS/AIMS PPM.
15. End.

Called by: None.

Subroutines called: INIT, ASPINT, WSPOWE, INPUT, TRANSP, TSTART, LOAD, PRESET, TCAS1 (optional), ANTGAN, FRUITA, DISMOD, TCSMOT, DISINT, ATMOD, INTLI, STATS, FILES

3.3.2 Subroutine: **INIT**

PURPOSE: To set initial values of all common variables.

INPUTS: All common variables. (Refer to TCAS SEM Data Dictionary, APPENDIX A.)

PROCEDURE: Set each common variable to its initial value.

OUTPUTS: Initial values for all common variables.

Called by: CIRCAS

Subroutines called: None.

3.3.3 Subroutine: **ASPINT**

PURPOSE: To initialize the array containing the total power transmitted using N whisper-shout levels.

INPUTS: None.

PROCEDURE: A loop is performed over all whisper-shout levels. At each level, the total power transmitted by the top (in the front, sides, and back) and bottom antennas is computed and stored in the appropriate array.

OUTPUT: The array containing the sum of the whisper-shout power levels for N transmitted levels.

VARIABLES OF INTEREST

Description	Variable Name
Total power radiated with N levels	ATSUMP

PROCESS:

1. Define 1 dB and 2 dB.
2. Define the minimum levels transmitted by the top and bottom antennas in watts.
3. Set total sum power = 0 when no whisper-shout levels are sent.
4. **LOOP** over all 83 priority levels.
   - A. Find the number of whisper-shout levels sent on the top antenna (front, right, left, and back lobes) and bottom antenna for a given priority level.
   - B. Compute the total power transmitted by the top and bottom antennas, and store this value in the appropriate position in the sum power array.
5. **END LOOP**
6. Return.

Called by: CIRCAS

Subroutines called: None.

3.3.4 Subroutine: WSPOWE

PURPOSE: To load the 83 levels of ATCRBS whisper-shout interrogation power for the TCAS II M antennas and store them in arrays that correspond to the location of the antennas.

INPUTS: Number of whisper-shout (w-s) levels for the top antennas (total of 79 levels) which are located at the front (24 levels), sides (20 levels each side), and back (15 levels) of the aircraft and the number of levels for the bottom antenna (4 levels). These levels were obtained from the TCAS II M Minimum Operational Standards (MOPS) (Reference 5).

PROCEDURE: The 79 whisper-shout levels that can be transmitted by the TCAS II M top antenna (24 on the front, 20 on each side, and 15 on the back) and the 4 whisper-shout levels that can be transmitted by the bottom antenna are computed and stored in the appropriate arrays.

OUTPUTS: Four arrays containing whisper-shout power levels by location of antenna.

VARIABLES OF INTEREST

Description	Variable Name
Whisper-shout levels of:	
Top-front antenna	IPOWF
Top-side antennas	IPOWS
Top-back antenna	IPOWB
Bottom antenna	IPOWBO

PROCESS:

1. Initialize the peak power for the top-front antenna to 49 dBm.
2. **LOOP** over the 24 whisper-shout power levels of the front antenna
   A. Calculate this power level by decreasing the peak power by 1 dB per level (starting at 49 dBm and decreasing to 26 dBm).

   B. Calculate the total radiated power of the top-front antenna.

3. **END LOOP**
4. Initialize the peak power for the top-side antennas to 45 dBm.
5. **LOOP** over the 20 levels (each side) of the side antennas.
   A. Calculate this power by decreasing the peak power by 1 dB per level (from 45 to 26 dBm).
   B. Calculate the total radiated power of the side antennas.
6. **END LOOP**
7. Initialize the peak power for the top-rear antenna to 40 dBm.
8. **LOOP** over the 15 levels of the back antenna.
   A. Calculate these levels by decreasing the peak power by 1 dB per level (from 40 to 26 dBm).
   B. Calculate the total radiated power of the back antenna.
9. **END LOOP**
10. Initialize the peak power for the bottom antenna to 36 dBm.
11. **LOOP** over the 4 levels of the bottom antenna.
    A. Calculate these levels by decreasing the peak power by 2 dB per level (from 36 to 30 dBm).
    B. Calculate the total radiated power of the bottom antenna.
12. **END LOOP**
13. Calculate the total combined radiated power of all the antennas.
14. Return.

Called by: CIRCAS

Subroutines called: None.

3.3.5 Subroutine: INPUT

PURPOSE: Load the aircraft deployment array and the interrogation and suppression rate arrays, and determine the number of each type of aircraft.

INPUTS: Interrogation and suppression rates from the DABS/ATCRBS/AIMS PPM, and aircraft characteristics data from the Los Angeles Basin model which includes latitude (degrees, minutes, seconds), longitude (degrees, minutes, seconds), altitude (feet mean sea level), type of aircraft, longitudinal velocity (nautical miles per second, positive in the westerly direction), latitudinal velocity (nautical miles per second, positive in the northerly direction), and vertical velocity (feet per second, positive in the upward direction).

PROCEDURE: This subroutine reads interrogation and suppression rates and loads the rate arrays. It also reads the aircraft deployment file and loads the deployment array. During this process, the total number of aircraft is counted, as well as the number of each of the three types of aircraft (ATCRBS, Mode S, and TCAS II M).

OUTPUTS: Interrogation and suppression rates, the total number of aircraft, the number of each type of aircraft (ATCRBS, MODE S, and TCAS II M), and the aircraft deployment file which contains, for each aircraft, the latitude (radians), longitude (radians), altitude (feet mean sea level), type (ATCRBS, Mode S, or TCAS II M), westward velocity (nautical miles per second), northward velocity (nautical miles per second), and upward velocity (feet per second).

VARIABLES OF INTEREST

Description	Variable Name
Number of aircraft	NAC
Number of ATCRBS-equipped aircraft	IATCR
Number of Mode S-equipped aircraft	IDAB
Number of TCAS II M-equipped aircraft	ITCA
Interrogation rates	IADJIN
Suppression rates	IADJSU
Aircraft deployment	TJFILE
Percentage of deployment	RATIO

PROCESS:

1. Set fraction of total deployment wanted (RATIO).
2. **LOOP** over all aircraft in model.
   - A. Read in the interrogation and suppression rates from DABS/ATCRBS/AIMS PPM and store them in appropriate arrays.
   - B. Read in the transponder deployment from the deployment file (usually the LA Basin Model).
   - C. CALL RANN: Get a random number.
   - D. **IF** random number greater than or equal to RATIO, **THEN**
     1. Eliminate this aircraft from deployment.
   - E. **ELSE**
     1. CALL FASCFD: Convert aircraft type from ASCII to fieldata.
     2. CALL CNVRT: Convert aircraft type from fieldata to integer representation (0 indicates an ATCRBS transponder, 1 indicates Mode S, and 3 indicates TCAS II M).
     3. Convert latitude and longitude data from degrees, minutes, and seconds to radians.
     4. Determine whether the latitudes are north or south, and whether the longitudes are east or west.
     5. Load the position, type, and velocity in the aircraft characteristics file.
     6. Count the number of each type of aircraft.
     7. Store the interrogation and suppression rates.

F. END IF

3. END LOOP

4. Return.

Called by: CIRCAS

Subroutines called: CNVRT, RANN

System routines used: FASCFD

3.3.6 Subroutine: **CNVRT**

PURPOSE: To determine the type of each aircraft and convert it from fieldata to integer form.

INPUTS: Aircraft type (in fieldata form).

PROCEDURE: The aircraft type is passed to this subroutine as fieldata. This data is evaluated and an integer value that indicates whether the aircraft is ATCRBS-, Mode S-, or TCAS II M-equipped is assigned to the type variable. This value is then passed back to the calling routine.

OUTPUTS: Aircraft type (in integer form).

VARIABLES OF INTEREST

Description	Variable Name
Aircraft type	ITYPE

PROCESS:

1. **CASE** the six most significant bits of aircraft type **OF**
   - A. 9: ITYPE = 1 (Mode S-equipped aircraft)
   - B. 7:25: ITYPE = 3 (TCAS II M-equipped aircraft)
   - C. Others: ITYPE = 0 (ATCRBS-equipped aircraft)
2. **END CASE**
3. Return.

Called by: INPUT

Subroutines called: None

3.3.7 Subroutine: **RANN**

PURPOSE: To generate a random number between zero and one.

INPUTS: None.

PROCEDURE: The first time this routine is performed, a large number is assigned to the "seed," which is the variable that is used to produce the random numbers. This seed is multiplied by an integer which is sufficiently large to cause an overflow of bits in the register holding the seed. The random number is obtained by shifting the bits back down such that the number is positive and no greater than one.

OUTPUTS: A random number having a value between zero and one.

VARIABLES OF INTEREST

Description	Variable Name
Random number between zero and one	RAN

PROCESS:

1. **IF** subroutine has not been run before **THEN**
   - A. Set seed equal to a large integer value.
   - B. Set flag that indicates subroutine has been run.
2. **END IF**
3. Multiply seed by a large integer value.
4. Produce random number by dividing the absolute value of the seed by (approximately) 2^{35}, which corresponds to the largest integer value the computer is capable of retaining.
5. Return.

Called by: INPUT, TRANSP, TSTART, DISMOD, TSQUIT

Subroutines called: None

3.3.8 Subroutine: **TRANSP**

PURPOSE: To assign transmit power and receiver sensitivity characteristics for each transponder.

INPUTS: Number of aircraft in model; nominal Mode S power and sensitivity, and standard deviations from each; and nominal TCAS II M power and sensitivity levels with corresponding standard deviations.

PROCEDURE: A normal distribution of random numbers is generated and used to assign the transmitter powers and receiver sensitivities of each Mode S and TCAS II M aircraft in the environment. The transmitter power and sensitivity for each ATCRBS aircraft is assigned using measured data documented in Reference 9.

OUTPUTS: Transponder characteristic arrays: Transmission power levels for each aircraft and receiver sensitivity for each aircraft.

VARIABLES OF INTEREST

Description	Variable Name
Transmission power for each aircraft	JTRANS
Sensitivities for each aircraft	JSENS

PROCESS:

1. Set starting points for random number generator.
2. CALL RANDN: Set up array of pseudo-random numbers which follow a normal distribution and are used to predict Mode S power levels (nominal value is 27.0; standard deviation is 1.5).
3. CALL RANDN: Set up array of pseudo-random numbers which follow a normal distribution and are used to predict TCAS II M power levels (nominal value is 29.2; standard deviation is 0.5).
4. **LOOP** over all aircraft in model.
   A. **IF** ATCRBS-equipped aircraft **THEN**
      1. CALL RANN: Get a random number.

2. Use probability distribution from ATC-9 to determine transmission power.
3. Store transmission power.

B. **ELSE IF** Mode S-equipped aircraft **THEN**

1. Calculate transmission power of Mode S-equipped aircraft using number from normal distribution.
2. Store transmission power.

C. **ELSE IF** TCAS II M-equipped aircraft **THEN**

1. Calculate transmission power using number from normal distribution.
2. Store the transmission power.

D. **END IF**

5. **END LOOP**
6. Set starting points for random number generator.
7. CALL RANDN: Set up array of psuedo-random numbers that follow a normal distribution and are used to predict Mode S sensitivity levels.
8. CALL RANDN: Set up array of psuedo-random numbers that follow a normal distribution and are used to predict TCAS II M sensitivity levels.
9. **LOOP** over all aircraft

A. **IF** ATCRBS-equipped aircraft **THEN**

1. CALL RANN: Get a random number.
2. Use probability distribution from ATC-9 to determine sensitivity level.
3. Store the sensitivity.

B. **ELSE IF** Mode S-equipped aircraft **THEN**

1. Set sensitivity equal to number from normal distribution.
2. Store the sensitivity.

C. **ELSE IF** TCAS II M-equipped aircraft **THEN**

1. Set sensitivity equal to number from normal distribution.
2. Store predicted value.

D. **END IF**

10. **END LOOP**

11. Return.

Called by: CIRCAS

Subroutines called: RANN

System routines used: RANDN

3.3.9 Subroutine: TSTART

PURPOSE: To set up a pointer array that locates TCAS II M-equipped aircraft in the aircraft deployment file, and to set the squitter phase for each TCAS II M-equipped aircraft.

INPUTS: Aircraft deployment file.

PROCEDURE: A loop is performed over all aircraft to determine and store the number of TCAS II M-equipped aircraft and the pointer arrays used to locate the TCAS II M in the aircraft file.

OUTPUTS: Number of TCAS II M-equipped aircraft, TCAS II M pointer file, and start time of each TCAS II M squitter phase.

VARIABLES OF INTEREST

Description	Variable Name
Number of TCAS II M-equipped aircraft	NUMTCA
TCAS II M pointer array	I111
Squitter phase start time	TCST

PROCESS:

1. **LOOP** over all aircraft.
   - A. **IF** TCAS II M **THEN**
     1. Count the aircraft.
     2. Store its location in the pointer file.
     3. CALL RANN: Get a random number.
     4. Calculate squitter phase start time using the random number.
   - B. **END IF**
2. **END LOOP**
3. Return.

Called by: CIRCAS

Subroutines called: RANN

3.3.10 Subroutine: LOAD

PURPOSE: At times 0, 40, 80, and 120 seconds: to update all aircraft positions; to compute heading of each TCAS II M (at time = 0 only); to update Mode S track file; to load array containing power, range, and bearing relationships between TCAS II M-equipped aircraft and victim aircraft; and to compute the air traffic densities about each TCAS II M, as well as the average density about all TCAS II M-equipped aircraft.

INPUTS: Aircraft deployment file, number of TCAS II M-equipped aircraft, Mode S track file, TCAS II M pointer file, simulation time, and the number of aircraft.

PROCEDURE: First, the velocity of each aircraft is used to update its location in the environment. The following data is then calculated and stored in the appropriate arrays: the relative position of other aircraft to each TCAS II M, the aircraft that belong in the track file, the power received by each TCAS II M from other aircraft, and the local air traffic densities within 5, 10, and 30 nmi of each TCAS II M.

OUTPUTS: Updated aircraft deployment file, updated Mode S track file, updated TCAS II M environmental array, and air traffic density about each TCAS II M within 10 nmi.

VARIABLES OF INTEREST

Description	Variable Name
Aircraft characteristics file	TJFILE
TCAS II M headings	THETA
Track file	ITRACK
TCAS II M environmental array	ICASFI
Density about each TCAS II M	DENS

Number of TCAS II M-equipped aircraft	NUMTCA
Simulation time	ITIME
TCAS II M pointer file	I111
Number of aircraft	NAC

PROCESS:

1. IF time does not equal zero **THEN**
   - A. Calculate the new latitude by adding forty seconds times the latitudinal velocity to the old latitude ($x = x_{t-40} + 40V_x$).
   - B. Calculate the new longitude by adding forty seconds times the longitudinal velocity to the old longitude ($y = y_{t-40} + 40\ v_y$).
   - C. Calculate the new altitude by adding forty seconds times the upward velocity to the old altitude ($z = z_{t-40} + 40\ v_z$).
   - D. Store these new positions.
2. **END IF**
3. **LOOP** over all TCAS II M-equipped aircraft
   - A. Find the location of the TCAS II M in the general aircraft characteristics file.
   - B. Compute the heading of the aircraft by finding the angle formed by the velocity components (theta = arcsin $(v_y/(v_x^2 + v_y^2)^{1/2})$).
   - C. Adjust the angle to fit into the coordinate system where north is at zero degrees, west is at 90, south is at 180, and east is at 270.
   - D. If the aircraft is heading eastward, subtract the adjusted angle in 3.C from 360°. (The calculation in 3.C assumes westward motion.)
   - E. Convert this angle to radians.
   - F. Zero out local aircraft counters.
   - G. Get the latitude (radians), longitude (radians), and altitude (statute miles) of the TCAS II M-equipped aircraft.
   - H. **LOOP** over all aircraft
     1. Get the victim aircraft's latitude (radians), longitude (radians), and altitude (miles).

2. CALL BEAR: Compute the horizontal distance (miles) and angle (radians) between TCAS II M and victim aircraft.
3. Find the altitude difference (nmi) between the TCAS II M and victim aircraft.
4. Find the slant range (straight-line distance) between the two aircraft. ((horizontal distance^2 + vertical distance^2) $^{1/2}$)
5. **IF** victim aircraft is TCAS II M- or Mode S-equipped **THEN**
   a. **IF** the two aircraft are within 50 nmi of each other **AND** their difference in altitude is less than 9000 feet
      THEN
      1. Add the victim aircraft to the track file if it is not already there.
   b. **ELSE**
      1. Remove the victim aircraft from the track file if it is there.
   c. **END IF**
6. **END IF**
7. Determine the free space power loss (Power loss = 37.80 + $20\log_{10}(1030)$ + $20\log_{10}$ slant range + 3.0 - 60.0) where 1030 is the interrogation frequency in MHz, the slant range is in nautical miles, 3.0 is the transponder cable loss in dB, 60.0 converts from kW to mW, and 37.80 is the constant adjustment factor to account for units of MHz and nmi).
8. Compute aircraft densities around each TCAS aircraft.
9. **IF** the two aircraft are separated by at least 50 nmi **THEN**
   a. Remove the victim aircraft from the TCAS II M environmental array.
10. **ELSE**
    a. Increment appropriate local aircraft counters if the victim is within 10 nmi of the TCAS II M.

b. Store the relative range, bearing, and power, and the type of victim aircraft in the TCAS II M environmental file.

11. **END IF**

I. **END LOOP**

4. **END LOOP**

5. Return.

Called by: CIRCAS

Subroutines called: BEAR

3.3.11 Subroutine: BEAR

PURPOSE: To calculate the horizontal distance and angle between the TCAS I or TCAS II M aircraft of interest and the victim aircraft (see Figure 3-2).

INPUTS: TCAS-equipped aircraft's latitude and longitude (in radians), the victim aircraft's latitude and longitude (in radians), and the radius of the earth (in statute miles).

PROCEDURE: The two-dimensional locations (latitude and longitude) of two aircraft are used to calculate the horizontal range and bearing relative to North using a flat earth approximation.

OUTPUTS: The horizontal distance between the two aircraft (in statute miles) and the bearing angle (measured from the north, in radians) between the two aircraft.

VARIABLES OF INTEREST

Description	Variable Name
Radius of the earth	RADIUS
TCAS latitude	TLAT
TCAS longitude	TLON
Victim latitude	RLAT
Victim longitude	RLON
Distance between the two aircraft	DIST
Bearing angle between the two aircraft	BEARTX

PROCESS:

1. Calculate the difference in latitudes between the two aircraft.
2. Calculate the difference in longitudes between the two aircraft.
3. Calculate the longitude scaling factor (the cosine of the average of the two latitudes).
4. Scale the difference in longitudes (multiply it by the scaling factor).

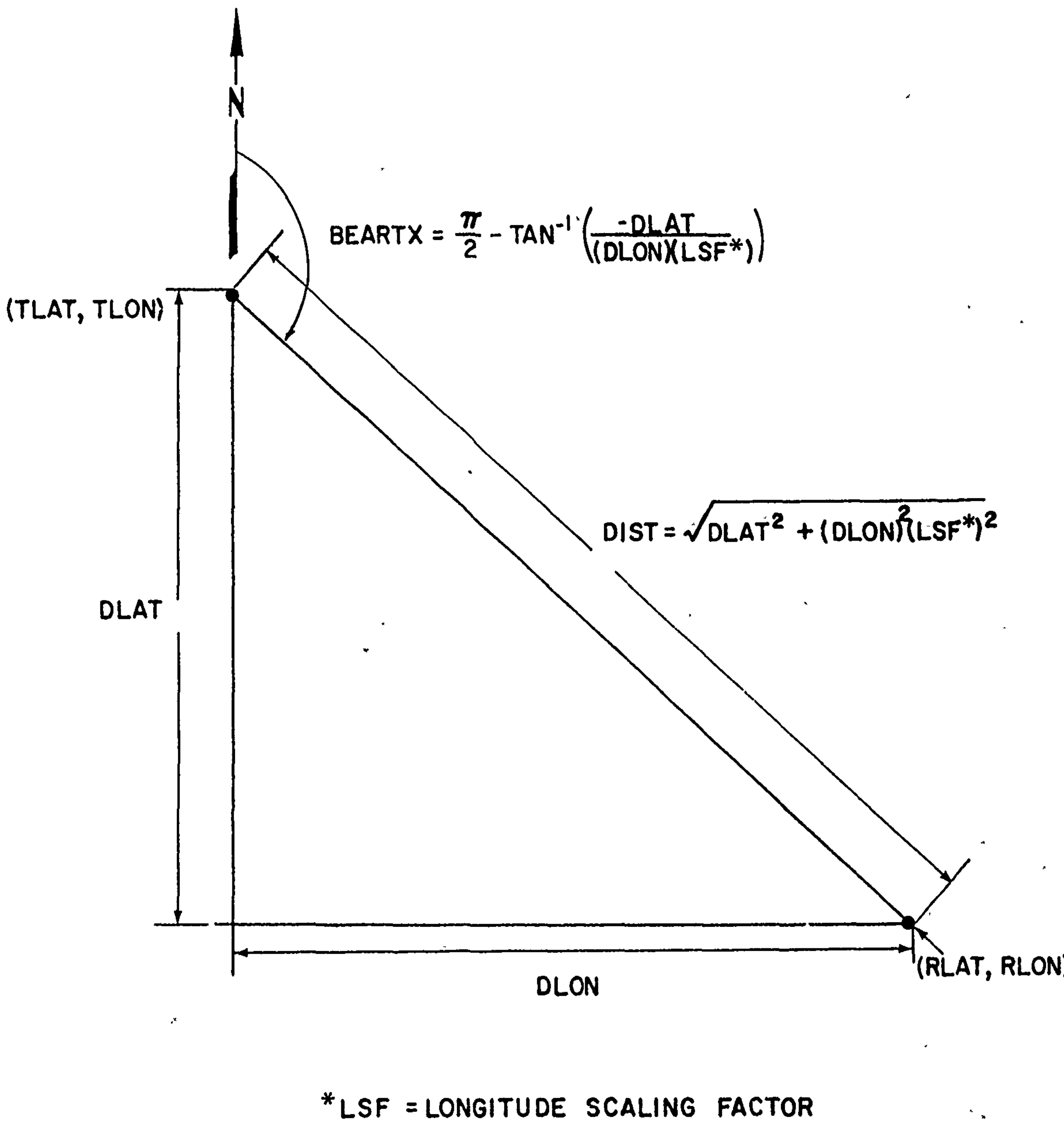

Figure 3-2. Illustration of bearing calculations.

5. Find the straight line distance between the two aircraft (the distance is the square root of the sum of the square of the difference in latitudes plus the square of the scaled difference in longitudes).
6. **IF** the difference in longitudes is less than one thousandth of a statute mile, **THEN**
   A. Set the difference in longitude to one thousandth of a statute mile to prevent division by zero in the bearing calculation.
7. **END IF**
8. Calculate the angle between the two aircraft (arctan (- difference in latitudes / scaled difference in longitudes)).
9. Adjust the axis so that due north is the zero point.
10. **IF** the angle is negative **THEN**
    A. Add 2π to it to make it positive.
11. **END IF**
12. Return.

Called by: LOAD, TCAS1

Subroutines called: None

3.3.12 Subroutine: PRESET

PURPOSE: To estimate the interference-limiting state of each TCAS II M-equipped aircraft.

INPUTS: Number of each type of aircraft, track file, TCAS II M environmental array, aircraft deployment file, and transponder characteristic arrays.

PROCEDURES: At the start of the simulation, the number of Mode S and TCAS II M-equipped aircraft within 35, 30, and 7.16 nmi of each TCAS II M aircraft are computed and used to estimate the number of aircraft in the squitter, acquisition, and roll-call states. Empirical estimates on the number of Mode S interrogations are made and used to preset the Mode S sensitivity and power levels according to the interference-limiting inequalities.

OUTPUTS: Adjusted transmission power and sensitivity levels for each TCAS II M-equipped aircraft.

VARIABLES OF INTEREST

Description	Variable Name
Number of:	
TCAS II M-equipped aircraft	NUMTCA, ITCA
Mode S-equipped aircraft	IDAB
Track file	ITRACK
TCAS II M environmental array	ICASFI
Aircraft deployment file	TJFILE
Transmission power for each aircraft	JTRANS
Adjusted transmission power for TCAS II M	AMSP
Sensitivity levels for each aircraft	JSENS
Adjusted sensitivities for TCAS II M-equipped aircraft	SESIT

PROCESS:

1. **LOOP** over all TCAS II M-equipped aircraft.
   - A. Reset squitter, acquisition, and roll-call target counters.
   - B. Get altitude of TCAS II M.
   - C. **LOOP** over all 500 tracks.
     1. Get aircraft number.
     2. If aircraft has been removed from file, go on to the next track.
     3. Get aircraft type.
     4. If ATCRBS-equipped aircraft, go on to the next track.
     5. Get slant range (nmi) between TCAS II M and victim.
     6. If slant range is over 35 nmi, go on to the next track.
     7. Increment the squitter count by one.
     8. If slant range is over 30 nmi, go on to the next track.
     9. Get altitude of victim.
     10. Find the difference in the altitudes of the two aircraft.
     11. If the difference in the altitudes is over 9000 feet, go on to the next track.
     12. If the slant range is greater than 7.16 nmi, increment the number in acquisition range.
     13. If the slant range is less than or equal to 7.16 nmi, increment the number in roll-call range.
   - D. **END LOOP**
   - E. Multiply the squitter count by the ratio of TCAS II M-equipped aircraft to all the Mode S-equipped aircraft (all TCAS II M-equipped aircraft are Mode S-equipped) to find the total number of squitter targets.
   - F. **DO WHILE** inequality (2-1) is not satisfied **AND** no more than seven adjustments have been made. (See Reference 6.)
     1. Make power and sensitivity adjustment.
     2. Compute interference-limiting equation.
   - G. **END WHILE**
   - H. Set up new array of sensitivities with adjustment calculated above.

I. Set up new array of transmission power with above adjustment.

2. **END LOOP**

3. Return.

Called by: CIRCAS

Subroutines called: None.

3.3.13 Subroutine: **TCAS1**

PURPOSE: To determine the effects of deploying TCAS I-equipped (all Mode S-equipped aircraft are assumed to be TCAS I-equipped) aircraft in the environment.

INPUTS: Aircraft deployment file, antenna patterns, and sensitivity levels.

PROCEDURE: For all aircraft in the environment, the received power from each TCAS I aircraft is calculated. If the received power is greater than the receiver sensitivity, the number of TCAS I interrogations received is incremented by one.

OUTPUTS: The expected number of TCAS I interrogations per second received at each aircraft.

VARIABLES OF INTEREST

Description	Variable Name
Aircraft deployment	TJFILE
Antenna patterns:	
Top (transmitting)	ANTTOP
Bottom (transmitting)	ANTBOT
Bottom (receiving)	PASBOT
Top (receiving)	PASTOP
Sensitivity levels	JSENS
Expected number of TCAS I interrogations per second	ATCRAT ATCRAT

PROCESS:

1. **LOOP** over all aircraft, selecting only TCAS I-equipped aircraft.
   - A. Get latitude, longitude, and altitude of TCAS I.
   - B. **LOOP** over all aircraft.
     1. Get latitude, longitude, and altitude of victim aircraft.
     2. CALL BEAR: Get horizontal distance between two aircraft.

3. Find the difference in altitudes (nmi).
4. Determine the angle between the aircraft.
5. Using that angle, look up the antenna gains for top and bottom antennas.
6. Determine total gain (add TCAS I gain to victim gain).
7. Calculate free space power loss.
8. Using results from 1.B.6 and 1.B.7, find received power.
9. **IF** received power is above sensitivity level of victim (i.e., signal is detectable) **THEN**
   a. Count one interrogation at that aircraft.
10) **END IF**

C. **END LOOP**

2. **END LOOP**
3. Return.

Called by: CIRCAS

Subroutines called: BEAR

3.3.14 Subroutine: **ANTGAN**

PURPOSE: To store elevation antenna patterns between TCAS II M-equipped aircraft and victim aircraft.

INPUTS: Aircraft deployment file, TCAS II M environmental file, TCAS II M-equipped pointer file, antenna gains, and TCAS II M-equipped aircraft identity.

PROCEDURE: The antenna coupling between each TCAS II M aircraft and all other aircraft is computed based on the elevation angle between the aircraft. The value of the antenna coupling is stored in the aircraft deployment file.

OUTPUTS: Aircraft deployment file.

VARIABLES OF INTEREST

Description	Variable Name
Aircraft deployment file	TJFILE
TCAS II M environmental file	ICASFI
TCAS II M pointer file	I111
Antenna patterns:	
Top (transmitting)	ANTTOP
Bottom (receiving)	PASBOT
Bottom (transmitting)	ANTBOT
Top (receiving)	PASTOP

PROCESS:

1. Find the location of the TCAS II M in the aircraft deployment file.
2. Get the altitude of the TCAS II M.
3. **LOOP** over all aircraft.
   - A. Reset the gain column of the aircraft deployment file.
   - B. **IF** the aircraft is within 50 nmi of the TCAS II M **THEN**
     1. Get the aircraft's altitude.

2. Get the slant range between the two.
3. Calculate the difference in their altitudes.
4. Calculate the horizontal distance between them.
5. Calculate the elevation angle between the two aircraft.
6. Look up the couplings at the calculated angles and interpolate to find a more exact approximation.
7. Store the couplings.

C. **END IF**

4. **END LOOP**
5. Return.

Called by: CIRCAS

Subroutines called: None.

3.3.15 Subroutine: **FRUITA**

PURPOSE: To determine the fruit received at the TCAS II M-equipped aircraft. To compute the reply efficiency for each aircraft.

INPUTS: Interrogation and suppression rates for each aircraft, TCAS II M environmental array, aircraft deploymemt file, TCAS II M-equipped aircraft identity, transmission power and sensitivities for each aircraft.

PROCEDURE: For all aircraft in the environment, the probability of reply is calculated from the dead time caused by all incoming interrogations and suppressions. The ATCRBS fruit rate due to a given aircraft is the product of the received ATCRBS interrogation rate times the probability of reply. The total fruit rate at each TCAS II M aircraft is found by summing the fruit rates contribution from all aircraft within range of the TCAS II M aircraft.

OUTPUTS: Fruit seen by TCAS II M, probability of reply for each aircraft.

VARIABLES OF INTEREST

Description	Variable Name
Interrogation rate for each aircraft	IADJIN
Suppression rate for each aircraft	IADJSU
TCAS II M environmental array	ICASFI
Aircraft deployment file	TJFILE
Interrogation and suppression totals from previous second	STAT
Misaddressed totals from previous second	MIS
TCAS II M identity	II
Transmission power for each aircraft	JTRANS
Sensitivity level for each aircraft	JSENS
Fruit level seen by TCAS II M-equipped aircraft	FRUIT
Probability of reply for each aircraft	PREP

PROCESS:

1. **IF** at the beginning of a new search cycle **THEN**
   - A. **LOOP** over all aircraft.
     1. Save misaddressed totals from last second.
     2. Save interrogation totals from last second.
     3. Save suppression totals from last second.
   - B. **END LOOP**
2. **END IF**
3. Locate the TCAS II M aircraft in the list of aircraft.
4. Zero out fruit counter for the TCAS II M.
5. **LOOP** over all aircraft.
   - A. If victim aircraft is out of range of the TCAS II M, go on to the next aircraft.
   - B. Find the type of the victim aircraft.
   - C. Get number of interrogations victim received during the previous second.
   - D. Get suppressions of victim from previous second.
   - E. **IF** ATCRBS-equipped aircraft **THEN**
     1. Set suppression time to 35 microseconds.
     2. Set dead time due to interrogations to 60 microseconds.
   - F. **ELSE**
     1. Set suppression time to 20 microseconds.
     2. Set interrogation dead time to 24 microseconds.
   - G. **END IF**
   - H. Calculate the total dead time due to interrogations.
   - I. Calculate the total dead time due to ground ATC, TCAS II M suppressions, and TCAS II M misaddresses.
   - J. Sum the above to find the total dead time.
   - K. Estimate and store the probability of reply for that aircraft.
   - L. Compute antenna coupling between victim and TCAS II M-equipped aircraft.
   - M. Get propagation loss between TCAS II M-equipped aircraft and victim aircraft from TCAS II M environmental file.

N. Add this power to the transmission power of the victim in dBm plus a constant adjustment factor.

O. Make further adjustments if victim aircraft is TCAS II M-equipped.

P. Add this power to the gain to get total power.

Q. **IF** total power is greater than the TCAS II M-equipped aircraft's sensitivity, **THEN**

1. Compute and store the fruit received at TCAS II M-equipped aircraft from victim aircraft.

R. **END IF**

6. **END LOOP**

7. Return.

Called by: CIRCAS

Subroutines called: None.

3.3.16 Subroutine: DISMOD

PURPOSE: To schedule Mode S discrete interrogations.

INPUTS: Adjusted TCAS II M sensitivities, TCAS II M environmental file, TCAS II M identity, aircraft deployment file, fruit level seen by each TCAS II M, adjusted TCAS II M power levels, misaddresses, total interrogations received by each aircraft, maximum interrogation failures allowed for each scan of each acquisition trial, aircraft sensitivities, Mode S track file, TCAS II M pointer file, simulation time, and aircraft transmission powers.

PROCEDURE: Each aircraft in the track file of the TCAS II M is examined and its state is determined. Using statistical methods, this subroutine schedules discrete Mode S interrogations and simulates the development of target track states. The victim aircraft are moved from state to state as necessary and the various timers are adjusted as necessary.

OUTPUTS: Mode S replies received at each TCAS II M-equipped aircraft, Mode S addresses to each aircraft, Mode S interrogation counter, number of victim aircraft in dormancy, acquisition counter, dormancy counter, roll call counter, squitter state counter, null state counter, number of aircraft TCAS II M has of interest in roll call, top or bottom antenna indicator, victim aircraft identity, the number of TCAS II M transmissions, and the Mode S track file.

VARIABLES OF INTEREST

Description	Variable Name
Adjusted TCAS II M sensitivities	SESIT
Interrogation rate at each TCAS II M	DRATE
TCAS II M environmental file	ICASFI
TCAS II M identifier	II
Type of each aircraft	IJFILE
Aircraft deployment file	TJFILE

Fruit level seen by each TCAS II M	FRUIT
Adjusted TCAS II M power levels	AMSP
Misaddresses	MIS
Addresed rate to each aircraft	DINTRT
Total number of interrogations received	UPRATE
Maximum interrogation rate in roll call	IROL
Maximum failed interrogations/scan	
Trial 1	ITRIL1
Trial 2	ITRIL2
Trial 3	ITRIL3
Trial 4 and above	ITRIL4
Mode S interrogation rate count	ACQSUM
Number of aircraft in dormancy state	DORSUM
Acquisition counter	MAQ
Dormancy counter	MDOR
Roll call counter	MROL
Squitter state counter	MSQ
Null state counter	NULL
Number of aircraft in roll call	ROLSUM
Aircraft sensitivities	JSENS
Indicates where TCAS II M transmitted	ITOB
Victim aircraft	K
TCAS II M transmissions	LPLUS
Mode S track file	ITRACK
TCAS II M pointer file	I111
Elapsed time in simulation	ITIME
Aircraft transmission powers	JTRANS

PROCESS:

1. **IF** at the beginning of a search cycle **THEN**
   A. Zero out counters for roll call, dormancy, acquisition, and null states, as well as the interrogation, suppression, and misaddress counter arrays.

2. **END IF**
3. Set the number of Mode S tracks to 500.
4. Zero out the interrogation counter at the TCAS II M.
5. Locate TCAS II M in aircraft characteristics file.
6. Find the altitude of the TCAS II M in statute miles.
7. Initialize the number of interrogations sent by TCAS II M to zero.
8. Initialize the number of other TCAS II M-equipped aircraft detected by the given TCAS II M to zero.
9. **LOOP** over the 500 tracks.
   - A. Skip if there is no aircraft in this track.
   - B. Get identity of aircraft in track.
   - C. Determine the floating point and integer averages of the number of interrogations received by the victim aircraft.
   - D. Find the difference between the floating point and integer averages.
   - E. CALL RANN: Get a random number.
   - F. **IF** the random number is greater than the fractional portion of the average **THEN**
     - 1. Add one to the integer average.
   - G. **END IF**
   - H. **IF** the integer average is less than one **THEN**
     - 1. Set it equal to one.
   - I. **END IF**
   - J. Find the altitude of the victim aircraft in statute miles.
   - K. Find the absolute difference in the altitudes of the two aircraft.
   - L. Get the slant range between the two aircraft.
   - M. Find the victim aircraft type.
   - N. Skip the rest of this loop if victim is ATCRBS-equipped.
   - O. Get the received power at the victim aircraft from the TCAS II M transmissions.
   - P. Find the interrogation power of the TCAS II M.
   - Q. Find the reply power of the victim.

R. Determine the antenna gains of the TCAS II M-equipped aircraft and the victim aircraft and sum them to find the total gain.

S. The total interrogation power is the quantity found in 9.P plus the total gain.

T. The total reply power is the quantity found in 9.Q plus the total gain.

U. **IF** the victim aircraft is TCAS II M equipped **AND** its reply power is above the sensitivity of the TCAS II M **THEN**

   1. CALL TSQUIT: Count the TCAS II M-equipped aircraft detected by squitter and set the squitter start time.

V. **END IF**

W. **IF** the fruit seen by the TCAS II M-equipped aircraft is less than 100 **THEN**

   1. Set the fruit level to 100.

X. **END IF**

Y. Find the probability of clear reception of the victim aircraft's reply signal by the TCAS II M-equipped aircraft using a curve-fitting technique. (The probability of clear reception depends on the received power and the fruit level seen by the TCAS II M. The curves were supplied by Lincoln Laboratory and are sinusoidal in nature on the intervals under consideration.)

Z. Find the maximum relative velocity of the two aircraft.

AA. Find the Time to Endanger (TE = range/maximum relative velocity).

BB. Set the decode indicator to zero (false).

CC. Get the trial, scan, clock, and state values from the Mode S track file.

DD. **IF** the victim's reply power is below the TCAS II M-equipped aircraft's transponders instantaneous sensitivity **THEN**

   1. Set the probability of decode to zero.

EE. **END IF**

FF. **IF** the victim's reply power is below the TCAS II M sensitivity **OR** the victim is currently in the null state **THEN**

1. Set the number of squitters received equal to zero.
2. Increment the null state counter by one.
3. CALL RANN: Get a random number.
4. **IF** the random number is less than the probability of decode **AND** the aircraft is in the null state **THEN**
   a. Increment the number of received squitters by one.
5. **END IF**
6. **IF** the TCAS II M received one squitter from the victim **THEN**
   a. Place the aircraft in the squitter state.
   b. Set the timer to 16 seconds. (This is the time during which a second squitter must be received in order for the aircraft to be placed in a higher state).
7. **ELSE**
   a. Place the aircraft in the null state.
   b. Set the timer to zero.
   c. Set the scan number to zero.
   d. Set the trial to zero.
   e. Set the acquisition correlating reply indicator equal to zero.
8. **END IF**

GG. **ELSE IF** the aircraft is in the squitter state **THEN**

1. Decrement the timer by one.
2. Increment the squitter state counter by one.
3. **IF** the sequence of scans has begun **THEN**
   a. **IF** on the first scan **THEN**
      1. Set the clock increment to 20.
   b. **ELSE IF** on the second scan **THEN**
      1. Set the clock increment to 16.
   c. **ELSE IF** on the third scan **THEN**
      1. Set the clock increment to 8.
   d. **ELSE IF** on the fourth scan **THEN**
      1. Set the clock increment to 4.

e. **ELSE**

1. Set the clock increment to 2.

f. **END IF**

g. **LOOP** over the average number of TCAS II M interrogations.

1. CALL RANN: Get a random number.

2. **IF** the random number is less than the probability of decode **THEN**

a. Add the clock increment to the timer.

b. Set the decode indicator to one (true).

3. **END IF**

4. **IF** the clock has reached or exceeded zero **THEN**

a. Put the victim aircraft in the acquisition state.

b. Set the scan indicator to zero.

c. Proceed to the next trial.

d. **IF** the trial number is greater than four **THEN**

1. Set the trial to four.

e. **END IF**

f. Zero out the clock.

g. Store the clock, trial, scan, and state values.

h. Return.

5. **END IF**

h. **END LOOP**

i. CALL RANN: Get a random number.

j. **IF** the random number is less than the probability of clear reply **THEN**

1. Add the clock increment to the timer.

k. **END IF**

l. **IF** the timer has reached or exceeded zero **THEN**

1. Put the victim aircraft in the acquisition state.

2. Set the scan indicator to zero.

3. Proceed to the next trial.
4. **IF** the trial number is greater than four **THEN**
   a. Set the trial number to four.
5. **END IF**
6. Zero out the clock.

m. **ELSE IF** the timer is less than or equal to -40 **THEN**
   1. Place the aircraft in the null state.
   2. Set the trial and scan indicators to zero.
   3. Zero out the clock.
   4. Set the acquisition reply indicator to zero.

n. **END IF**

4. **ELSE IF** the timer is greater than or equal to -1 **THEN**
   a. Set the number of squitters received to zero.
   b. **LOOP** over one less than the average number of TCAS II M interrogations.
      1. CALL RANN: Get a random number.
      2. **IF** the random number is less than the probability of decode **THEN**
         a. Set the decode indicator to one (true).
         b. Add one to the number of squitters received.
         c. **END LOOP**
      3. **END IF**
   c. **END LOOP**
   d. CALL RANN: Get a random number.
   e. **IF** the random number is less than the probability of clear reply **THEN**
      1. Add one to the number of squitters received.
   f. **END IF**
   g. **IF** the number of squitters received is not equal to zero **THEN**
      1. **IF** a squitter has been correctly decoded **AND** the altitudes of the two aircraft differ by more than 9000 feet **THEN**
         a. Set the clock to 16 seconds.

2. **ELSE**

a. Place the victim aircraft in the acquisition state.

b. Increment the trial number if it is less than four.

c. Set the clock to zero.

3. **END IF**

h. **END IF**

5. **ELSE**

a. Set the clock to zero.

b. Place the aircraft in the null state.

c. Set the trial and scan indicators to zero.

d. Set the acquisition reply indicator to zero.

6. **END IF**

HH. **ELSE IF** the victim aircraft is in the acquisition state **THEN**

1. Increment the scan indicator.

2. Increment the acquisition counter.

3. **IF** all six scans of the trial sequence have been completed **THEN**

a. Place the victim aircraft in the squitter state.

b. Set the scan back to zero.

c. Set the clock to zero.

d. Set the acquisition reply indicator to zero.

4. **ELSE**

a. Look up the number of failed interrogations allowed during this scan.

b. **IF** the number of failed interrogations is not equal to zero **THEN**

1. Set the correlating reply counter to zero.

2. **DO WHILE** the TCAS II M has received less than two correlating replies **AND** the maximum number of failures has not been exceeded.

a. CALL RANN: Get a random number between zero and one.

b. Increment the TCAS II M transmission counter by one.

c. Determine from which TCAS II M antenna the victim aircraft received the interrogation.

d. Add one to the Mode S interrogation rate counter.

e. Increment the TCAS II M interrogation rate counter.

f. **IF** the interrogation power received by the victim is greater than or equal to its sensitivity **THEN**

   1. Increment the Mode S address counter.

   2. **IF** the random number is less than the probability of the TCAS II M receiving a correlating reply **THEN**

      a. Increment the correlating reply counter.

   3. **END IF**

   4. **IF** the TCAS II M has received two correlating replies **THEN**

      a. Set the scan and trial indicators to zero.

      b. Reset the acquisition reply indicator.

      c. **IF** the time to endanger is greater than 43 seconds **THEN**

         1. Place the victim aircraft in the dormancy state.

         2. Set the clock to the time to endanger minus 43 seconds.

         3. Increment the dormancy counter.

d. **ELSE**

1. Place the victim aircraft in the roll call state.

2. Set the clock to zero.

e. **END IF**

5. **END IF**

g. **END IF**

4. **END WHILE**

5. **IF** the TCAS II M-equipped aircraft received one and only one reply during the scan **THEN**

a. **IF** this was the final scan **OR** a reply was received during a previous scan **THEN**

1. **IF** the time to endanger is greater than 43 seconds **THEN**

a. Set the trial, scan, and reply indicators to zero.

b. Place the victim aircraft in the dormancy state.

c. Set the clock to the time to endanger minus 43 seconds.

d. Add one to the dormancy counter.

2. **ELSE IF** a reply was received during a previous scan (but the time to endanger is within 43 seconds) **THEN**

a. Place the aircraft in the roll call state.

b. Set the clock to zero.

c. Set the scan, trial, and reply indicators to zero.

3. **END IF**

b. **ELSE** (if this wasn't the final scan and no other replies have been received)

1. Set the reply indicator to one.

c. **END IF**

6. **END IF**

c. **END IF**

5. **END IF**

II. **ELSE IF** the victim aircraft is in the roll call state **THEN**

1. Increment the scan indicator.
2. Increment the roll call counter.
3. **IF** all ten roll call scans have been completed **THEN**
   a. Place the victim aircraft in the squitter state.
   b. Set the clock to 16 seconds.
   c. Set the trial, scan, and reply indicators to zero.
4. **ELSE**
   a. Find the maximum number of interrogations allowed.
   b. **DO UNTIL** a correlating reply is received.
      1. CALL RANN: Get a random number.
      2. Increment the TCAS II M interrogation counter.
      3. Determine the TCAS II M antenna from which the victim received the interrogation.
      4. Add one to the Mode S interrogation rate counter.
      5. Add one to the roll call interrogation counter.
      6. **IF** the interrogation power the victim aircrft received is above its sensitivity level **THEN**
         a. Add one to the Mode S address counter.
         b. **IF** the random number is below the probability of a correlating reply **THEN**
            1. Set the scan indicator to zero.
            2. **IF** the time to endanger is greater than 40 seconds **THEN**
               a. Place the aircraft in dormancy.
               b. Increment the dormancy counter.
               c. Set the clock to the time to endanger minus 40 seconds.
            3. **END IF**
         c. **END IF**
      7. **END IF**

c. **END UNTIL**

5. **END IF**

JJ. **ELSE IF** the victim aircraft is in the dormancy state **THEN**

1. Decrement the clock.

2. Increment the dormancy counter.

3. **IF** there is no time left on the clock **THEN**

a. Place the aircraft in the squitter state.

b. Set the clock to 16 seconds.

c. Set the trial, scan, and reply indicators to zero.

4. **END IF**

KK. **END IF**

LL. Store the clock, state, scan, trial, and reply information.

MM. Total the number of TCAS II M interrogations made.

10. **END LOOP**

11. Return.

Called by: CIRCAS

Subroutines called: RANN, TSQUIT

3.3.17 Subroutine: TSQUIT

PURPOSE: To count the number of TCAS II M-equipped aircraft detected by squitters and to set the squitter phase.

INPUTS: TCAS II M identity, victim aircraft (also TCAS II M-equipped) identity, number of TCAS II M-equipped aircraft, TCAS II M pointer file, elapsed time in simulation, probability of reply for each aircraft, and the TCAS II M squitter phase.

PROCEDURE: The number of TCAS II M aircraft that are detected by squitter (NTADS) at each TCAS II M aircraft is incremented by one when the received power of the squitter is greater than the receiver sensitivity, the probability of reception of a pulse is sufficiently high, and the TCAS II M aircraft is not currently in the squitter file. The NTADS is decremented if the TCAS II M aircraft is in the squitter file and the elapsed time since the reception of the last squitter is greater than 20 seconds.

OUTPUTS: Number of TCAS II M-equipped victim aircraft detected, and the squitter phase for the given TCAS II M.

VARIABLES OF INTEREST

Description	Variable Name
TCAS II M identity	II
Victim aircraft identity	K
Number of TCAS II M detected	NOW
Number of TCAS II M-equipped aircraft	NUMTCA
TCAS II M pointer file	I111
Elapsed time in simulation	ITIME

Probability of reply for each aircraft PREP
TCAS II M squitter phase TCST

PROCESS:

1. Get the identity of the k-th TCAS II M aircraft.
2. Initialize time of last squitter if necessary.
3. Get time of last received squitter from squitter file.
4. Compute elapsed time since last received squitter (Δt).
5. **IF** time=1 **THEN**
   - A. Add to the squitter all TCAS II M aircraft that are detected and have a probability of reply greater than a random number.
   - B. Count the number of aircraft detected by squitter.
6. **ELSE IF** Δt>20 and k-th TCAS is in the squitter file, **THEN**
   - A. Decrement the number of TCAS detected by squitter by 1.
   - B. Delete k-th aircraft from the squitter file.
7. **ELSE IF** Δt = 0, 10, or 20 and the k-th TCAS is not in the squitter files, **THEN**
   - A. **IF** the received power is greater than the sensitivity, **THEN**
     1. Increment the number of TCAS detected by squitter by 1.
     2. Add k-th TCAS to squitter file.
   - B. **END IF**
8. **END IF**
9. RETURN

Called by: DISMOD
Subroutines called: RANN

3.3.18 Subroutine: TCSMOT

PURPOSE: To produce time-averaged values of the emission powers and interrogation rates of all TCAS II M-equipped aircraft over a 16-second smoothing period.

INPUTS: Total interrogations transmitted by each TCAS II M-equipped aircraft during the past second, TCAS II M-equipped aircraft, adjusted TCAS II M transmission power, TCAS II M pointer file, simulation time, and transmission powers of all aircraft.

PROCEDURE: For each TCAS II M aircraft, the Mode S interrogation power and interrrogation rates are stored for the previous 16 seconds of the simulation. The average power and rates are calculated using the stored values. If the simulation time is less than 16 seconds, the averages are computed for the entire simulation time.

OUTPUTS: Smoothed emission power and interrogation rate.

VARIABLES OF INTEREST

Description	Variable Name
TCAS II M identity	II
Total interrogations transmitted by each TCAS II M	DRATE
Adjusted TCAS II M transmission power	AMSP
Smoothed emission power	TIS
Smocthed interrogation rate	TPS
TCAS II M pointer file	I1M
Elapsed time in simulation	ITIME
Transmission power of each aircraft	JTRANS
Values of all TCAS II M emission powers and interrogation rates for the past 16 seconds	JTA

PROCESS:

1. Get location of TCAS II M-equipped aircraft of interest in general aircraft file.
2. **IF** at the beginning of a new search cycle **THEN**
   - A. Determine which column of the array holding all values of the interrogation rates and emission powers for the last sixteen seconds will be replaced with the new values.
   - B. **IF** simulation time is at least sixteen seconds, **THEN**
     - 1. Set smoothing period to sixteen seconds.
   - C. **ELSE**
     - 1. Set smoothing period to simulation time.
   - D. **END IF**
3. **END IF**
4. Round the interrogation rate to the nearest integer and store the rounded value in the array holding the values from the last sixteen seconds.
5. Compute the power emitted by the TCAS II M-equipped aircraft at its last transmission and store this as an integer value in the array holding the values from the last sixteen seconds.
6. Zero out the last smoothed values for this particular TCAS II M.
7. **LOOP** over smoothing time interval.
   - A. Sum the interrogation rates divided by the length of the time interval to produce the time-averaged rate.
   - B. Sum the emission powers divided by the length of the time interval to produce the time-averaged rate.
8. **END LOOP**
9. Return.

Called by: CIRCAS

Subroutines called: None.

3.3.19 Subroutine: DISINT

PURPOSE: To compute Mode S addressed and misaddressed rates at each aircraft.

INPUTS: Mode S interrogations transmitted by each TCAS II M-equipped aircraft, the TCAS II M-equipped aircraft identity, number of aircraft in deployment, number of ATCRBS-equipped aircraft in deployment, adjusted TCAS II M emission power, transponder characteristic files, array that indicates whether the TCAS II M transmitted on the top or bottom antenna, the number of TCAS II M transmissions, the number of TCAS II M-equipped aircraft, TCAS II M pointer file, and the simulation time.

PROCEDURE: For all aircraft within range of the TCAS II M, the received power from each TCAS II M aircraft is calculated. A misaddress is counted if the received power is above the victim sensitivity, and an addressed interrogation is counted for each Mode S-equipped aircraft.

OUTPUTS: Mode S misaddresses and addresses to each aircraft, total addresses each aircraft received during entire simulation, and total addresses each aircraft received during previous search cycle.

VARIABLES OF INTEREST

Description	Variable Name
Total interrogations transmitted by each aircraft	CBRATE
TCAS II M identity	II
Number of aircraft in deployment	NAC
Number of ATCRBS-equipped aircraft	IATCR
Adjusted TCAS II M emission power	AMSP
Misaddresses at each aircraft	MIS
Mode S interrogations transmitted during previous search cycle	DRATE
Total interrogations each aircraft received during entire simulation	UPRATE
Sensitivity levels of all aircraft	JSENS

Number of addressed interrogations received	ADRESS
Indicator of whether TCAS II M transmitted on its top or bottom antenna	ITOB
Number of TCAS II M transmissions	LPLUS
Number of TCAS II M-equipped aircraft	NUMTCA
TCAS II M pointer file	I111
Simulation time	ITIME
Transmission power for all aircraft	JTRANS

PROCESS:

1. Get TCAS II M identity.
2. **LOOP** over all aircraft.
   - A. Skip all aircraft not within range of TCAS II M.
   - B. Get antenna couplings between TCAS II M-equipped and victim aircraft.
   - C. Get victim aircraft type.
   - D. **LOOP** over all TCAS II M transmissions
     1. Determine which TCAS II M antenna transmitted the interrogation.
     2. Determine on which antenna the victim aircraft received the TCAS II M signal.
     3. Sum the gains associated with the two antennas above to determine the total gain.
     4. Get the free space propagation loss from the TCAS II M environmental file.
     5. Get the TCAS II M transmission power in watts and kilowatts.
     6. Calculate the total power loss in dB and add it to the total gain to determine the power received at the victim aircraft.
     7. If this power is greater than the victim sensitivity, count a misaddress.
   - E. **END LOOP**

3. **END LOOP**

4. **IF** at end of search cycle, **THEN**

   A. **LOOP** over all aircraft.

      1) **IF** not ATCRBS-equipped aircraft **THEN**

         a. Increment Mode S interrogation counter.

      2. **END IF**

      3. Add new Mode S addresses to all past addresses to get total for simulation.

      4. Set address rate equal to interrogation counter.

      5. Zero out interrogation counter.

   B. **END LOOP**

5. **END IF**

6. Return.

Called by: CIRCAS

Subroutines called: None.

3.3.20 Subroutine: ATMOD

PURPOSE: To determine the TCAS II M whisper-shout interrogation rate at each aircraft.

INPUTS: TCAS II M top antenna sum patterns, TCAS II M top antenna difference patterns, TCAS II M environmental file, antenna couplings between TCAS II M and victim aircraft, TCAS II M identity, number of aircraft in deployment, sensitivity level of all aircraft, TCAS II M pointer file, TCAS II M interrogations to ATCRBS-equipped aircraft, TCAS II M-produced ATCRBS suppressions, TCAS II M interrogations to Mode S, TCAS II M-produced Mode S suppressions, simulation time, transmission power levels of all aircraft, whisper-shout truncation, and elevation antenna patterns for all five TCAS II M antennas.

PROCEDURE: For each aircraft within 50 nmi of the given TCAS II M, the received power of each whisper-shout interrogation and suppression is computed. The number of suppressions received at the victim is incremented whenever the received power is greater than the victim receiver sensitivity, and the number of interrogations received is incremented when the received power is greater than the sensitivity and a suppression did not occur.

OUTPUTS: TCAS II M interrogations to ATCRBS, TCAS II M-produced ATCRBS suppressions, TCAS II M interrogations to Mode S, TCAS II M-produced Mode S suppressions.

VARIABLES OF INTEREST

Description	Variable Name
TCAS II M top antenna sum patterns	AZPAT
TCAS II M top antenna difference patterns	DIFPAT
TCAS II M environmental file	ICASFI
Antenna couplings beteen TCAS II M-equipped and victim aircraft	IJFILE

TCAS II M identity	II
Number of aircraft in deployment	NAC
Sensitivity levels of all aircraft	JSENS
TCAS II M pointer file	I111
TCAS II M interrogations to ATCRBS	IATIN
TCAS II M-produced ATCRBS suppressions	IATSU
TCAS II M interrogations to Mode S	IDABN
TCAS II M-produced Mode A suppressions	IDABS
Simulation time	ITIME
Transmission power of all aircraft	JTRANS
Whisper-shout truncation	ILWS
Truncation sequence:	
Back antenna	IPRB
Bottom antenna	IPRBO
Front antenna	IPRF
Side antennas	IPRS

PROCESS:

1. Get location of TCAS II M.
2. **LOOP** over all aircraft.
   - A. Skip if aircraft is out of TCAS II M range.
   - B. Find victim aircraft type.
   - C. Find relative bearing (in degrees) between two aircraft.
   - D. Get sensitivity of victim aircraft.
   - E. Get antenna couplings.
   - F. Find free space propagation loss between the two aircraft.
   - G. Get transmission power of TCAS II M in watts.
   - H. Find the total power without antenna gains (TCAS II M transmission power - free space propagation loss - cable losses).
   - I. **IF** the received signal is undetectable (less than -84 dBm) **THEN**
     1. **END LOOP**
   - J. **END IF**
   - K. Find gain at victim antenna.

L. Get integer designating 90 degree sector between TCAS II M and victim.

M. **LOOP** over five TCAS II M antennas.

1. **IF** integer designating 90 degree sector being analyzed is greater than 36 (360 degrees) **THEN**
    a. Set it equal to 36 (360 degrees).
2. **ELSE IF** integer designating 90 degree sector being analyzed is less than zero **THEN**
    a. Add 36 (360 degrees) to it to make it positive.
3. **ELSE IF** integer designating 90 degree sector equals zero **THEN**
    a. Set it equal to one (10 degrees).
4. **END IF**
5. Get sum antenna pattern.
6. Get difference antenna pattern.
7. Move to next 90-degree sector if next antenna is not a front antenna.
8. Set drop between whisper-shout emissions to 3 dB.
9. **LOOP** over all whisper-shout levels.
    a. **IF** analyzing bottom antenna **THEN**
        1. Get whisper-shout power from array IPRBOT.
    b. **ELSE IF** analyzing top front antenna **THEN**
        1. Get whisper-shout power from array IPRF.
    c. **ELSE IF** analyzing right side antenna **THEN**
        1. Get whisper-shout power from array IPRS.
    d. **ELSE IF** analyzing rear antenna **THEN**
        1. Get whisper-shout power from array IPRB.
    e. **ELSE** (left side antenna)
        1. Get whisper-shout power from array IPRS.
    f. **END IF**
    g. **IF** the amount of power cut in interference limiting exceeds or equals the whisper-shout power for the given antenna **THEN**
        1. **END LOOP**

h. **END IF**

i. Subtract the level being analyzed from the total number of levels to get the total attenuation.

j. Find the interrogation power by subtracting the attenuation from the total power.

k. Find the suppression power by subtracting the whisper-shout power drop from the interrogation power.

l. If at the first level of the sequence, set the suppression power to -100 dBm.

m. Decrement the whisper-shout power drop by one.

n. **IF** the whisper-shout power drop is less than one dB **THEN**

   1. Set the whisper-shout power drop equal to 3 dB.

o. **END IF**

p. **IF** the whisper-shout power drop is equal to 1 dB **AND** the victim aircraft is ATCRBS-equipped **THEN**

   1. Set the whisper-shout power drop to 3 dB.

q. **END IF**

r. Find the total antenna gain by adding the appropriate TCAS II M gain to the victim aircraft gain.

s. Find the sum interrogation power by summing the TCAS II M sum antenna gain, the interrogation power, and the total antenna gain.

t. Sum the interrogation power, the TCAS II M difference antenna pattern, and the total antenna gain to find the interrogation difference power.

u. Sum the suppression power, the sum antenna pattern, and the total antenna gain to find the suppression sum power.

v. Zero out the omnidirectional antenna's interrogation power.

w. **IF** analyzing bottom front antenna **THEN**

   1. Set omnidirectional power equal to the sum of the total power and the total antenna gain.

2. **IF** at first level of whisper-shout **THEN**
   a. Subtract 19 dB from the omnidirectional power.
   b. **IF** victim aircraft is an ATCRBS-equipped aircraft **THEN**
      1. Set omnidirectional suppression power to -110 dBm.
   c. **ELSE**
      2. **IF** at first level of whisper-shout **THEN**
   d. **END IF**
3. **ELSE IF** at second whisper-shout level **THEN**
   a. Subtract 17 dB from omnidirectional interrogation power.
   b. Set omnidirectional suppression power 3 dB lower than omnidirectional interrogation power.
4. **ELSE IF** at third whisper-shout level **THEN**
   a. Subtract 15 dB from omnidirectional interrogation power.
   b. Set omnidirectional suppression power 3 dB lower than omnidirectional interrogation power.
5. **ELSE IF** at last whisper-shout level **THEN**
   a. Subtract 13 dB from omnidirectional interrogation power.
   b. Set omnidirectional suppression power 3 dB lower than omnidirectional interrogation power.
6. **END IF**
7. Set difference interrogation power, sum interrogation power, and sum suppression power to zero.

8. **IF** omnidirectional suppression power is greater than or equal to victim sensitivity **THEN**
    a. Add a suppression at victim in Mode S suppressions array if victim is Mode S- or TCAS II M-equipped, or in ATCRBS suppressions array if victim is ATCRBS-equipped.
9. **ELSE IF** omnidirectional interrogation power is greater than or equal to victim sensitivity **THEN**
    a. Add an interrogation at the victim aircraft to the ATCRBS interrogations array or the Mode S/TCAS II M interrogations array, depending on whether the victim is Mode S/TCAS II M-equipped or ATCRBS-equipped.
10. **END IF**

x. **ELSE**

1. **IF** sum suppression power is greater than or equal to victim sensitivity **THEN**
    a. Add a suppresion at victim in Mode S suppressions array if victim is Mode S- or TCAS II M-equipped, or in ATCRBS suppressions array if victim is ATCRBS-equipped.
2. **ELSE IF** sum interrogation power is greater than difference interrogation power **AND** sum interrogation power is greater than or equal to victim sensitivity **THEN**
    a. Add an interrogation at the victim aircraft to the ATCRBS interrogations array or the Mode S/TCAS II M interrogations array, depending on whether the victim is Mode S/TCAS II M-equipped or ATCRBS-equipped.
3. **END IF**

y. **END IF**

10. **END LOOP**

N. **END LOOP**

3. **END LOOP**

4. Return.

Called by: CIRCAS

Subroutines called: None.

3.3.21 Subroutine: INTLI

PURPOSE: To adjust TCAS II M power and sensitivity as necessary to ensure that the three interference limiting inequalities are satisfied.

INPUTS: Adjusted sensitivity levels of TCAS II M-equipped aircraft, TCAS II M identity, adjusted power levels of TCAS II M, sensitivity levels of all aircraft, number of TCAS II M-equipped aircraft detected, smoothed emission powers, smoothed interrogation rates, TCAS II M pointer file, elapsed time, and transmission power of all aircraft.

PROCEDURE: Interference-limiting adjustments are made to satisfy the following three inequalities:

$$\sum_{i=1}^{I} \frac{P(i)}{250 \text{ watts}} < \frac{280}{1 + NTA} \qquad (2\text{-}1)$$

$$\sum_{i=1}^{I} M(i) < 0.01 \text{ second} \qquad (2\text{-}2)$$

$$\sum_{k=1}^{K} \frac{PA(k)}{250 \text{ watts}} \leq \frac{80}{1 + NTA} \qquad (2\text{-}3)$$

The symbols in the above equations were described in Section 2. Figure 3-2 illustrates the logic flow of the interference-limiting process.

OUTPUTS: Adjusted sensitivity level of TCAS II M, adjusted power level of TCAS II M, 16-second freeze counter, inequality (2-3) satisfaction indicator, total ATCRBS power radiated, peak ATCRBS power, whisper-shout truncation, and number of TCAS II M-equipped aircraft detected.

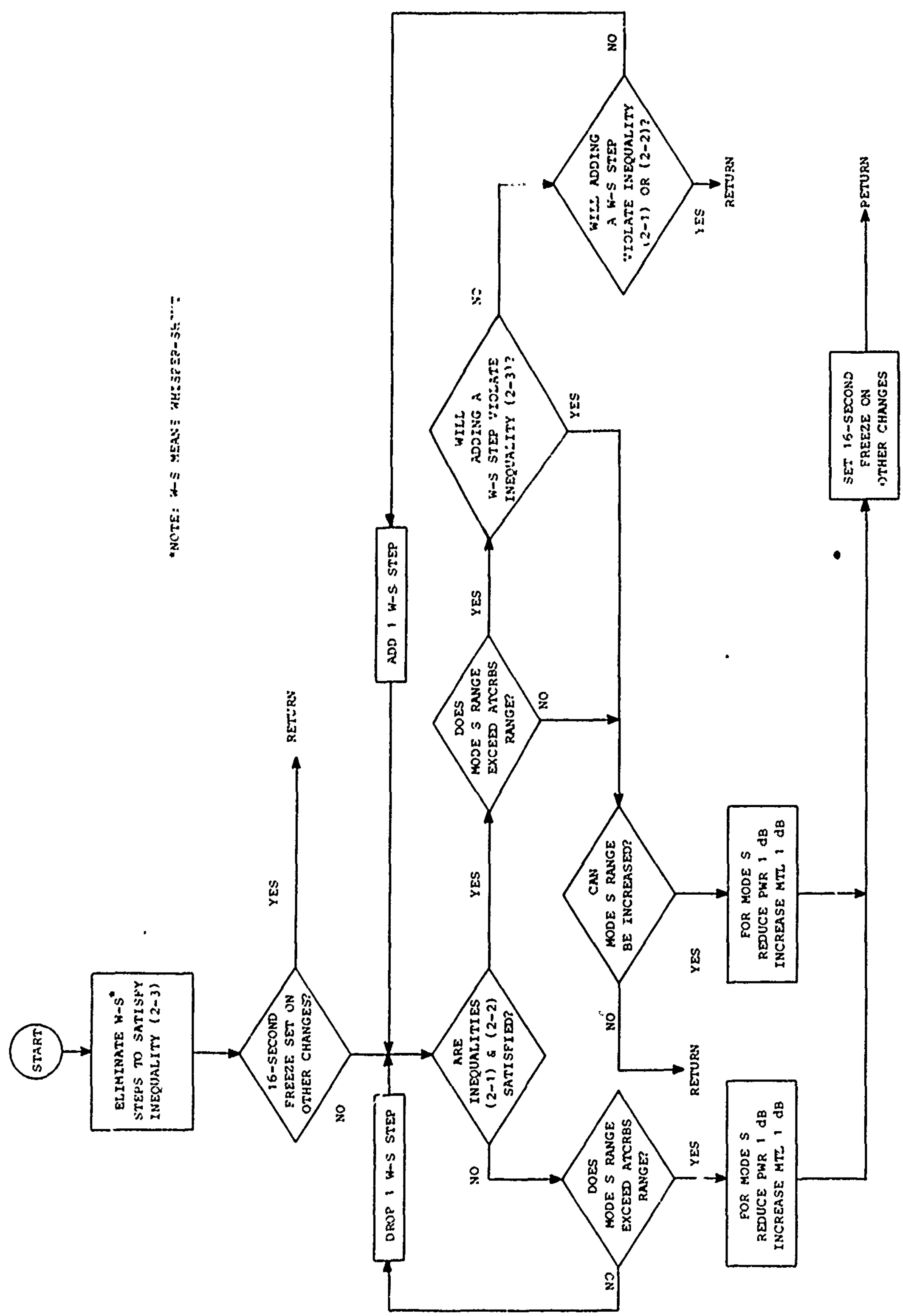

Figure 3-3. Interference-limiting algorithm flow diagram.

VARIABLES OF INTEREST

Description	Variable Name
Adjusted sensitivity levels of TCAS II M-equipped aircraft	SESIT
TCAS II M identity	II
Adjusted power levels of TCAS II M	AMSP
16-second freeze counter	IRESET
Whisper-shout steps allowed for each TCAS II M	NWSL
Peak ATCRBS power	PMAX
Total ATCRBS power radiated	TPOW
Sensitivity levels of all aircraft	JSENS
Number of TCAS II M-equipped aircraft detected	NOW
Smoothed emission powers	TIS
Smoothed interrogation rates	TPS
TCAS II M pointer file	I111
Elapsed time	ITIME
Transmission power of all aircraft	JTRANS
Return Point Indicator	IRETRN

PROCESS:

1. Get identity of TCAS II M-equipped aircraft.
2. Decrement 16-second freeze counter.
3. Compute right-hand side of Equations 1 and 3 (RSEQ1, RSEQ3).
4. Eliminate whisper-shout (w-s) steps to satisfy Equation 3.
   - A. **IF** the sum of the power over all whisper-shout steps is greater than RSEQ3, **THEN**
     1. **IF** number of whisper-shout level (NWSL) = 0, **THEN**
        - a. Set return indicator to 0.
        - b. Return.
     2. **END IF**
     3. Remove 1 w-s level.
     4. Go to step 5.

B. **END IF**

5. Check 16-second freeze clock.

6. **IF** freeze clock > 0, **THEN**

   1. Set return indicator to 1

   2. Return.

7. **ELSE**

   A. Check Equations 1 and 2.

   B. Compute total Mode S power transmitted.

   C. Compute total w-s power transmitted.

   D. Compute total Mode S + w-s power.

   E. Compute total self-suppression deadtime.

   F. **IF** Equation 1 and Equation 2 are satisfied, **THEN**

      1. **IF** Mode S range is greater than ATCRBS range, **THEN**

         a. Check to see if all w-s levels are used.

         b. Compute total w-s power radiated with 1 additional w-s level.

         c. **IF** Equation 3 is satisfied with new total w-s power, **THEN**

            1. **IF** Equations 1 and 2 are satisfied with one additional w-s step, **THEN**

               a. Add 1 w-s level.

               b. Go to Step 7.

            2. **ELSE**

               a. Set return indicator to 3.

               b. Return.

            3. **END IF**

         d. **END IF**

      2. **END IF**

      3. **IF** Instantaneous Mode S power is less than maximum Mode S power and instantaneous sensitivity is greater than minimum sensitivity, **THEN**

         a. Increase Mode S power by 1 dB.

         b. Decrease sensitivity by 1 dB.

         c. Reset freeze counter.

d. Set return indicator to 4.

e. Return.

4. **ELSE**

a. Set return indicator to 5.

b. Return.

5. **END IF**

G. **ELSE**

1. **IF** Mode S range is greater than ATCRBS range, **THEN**

a. Decrease Mode S power by 1 dB.

b. Increase sensitivity by 1 dB.

c. Reset freeze counter.

d. Set return indicator to 6.

e. Return.

2. **ELSE**

a. Delete 1 w-s level

b. Go to step 7.

3. **END IF**

H. **END IF**

8. **END IF**

9. Return

10. End

Called by: CIRCAS

Functions called: HIATPW

3.3.22 FUNCTION HIATPW

PURPOSE: This function determines the highest whisper-shout power sent when a total of N whisper-shout steps are transmitted.

INPUTS: Number of whisper-shout levels used.

PROCEDURE: The highest power transmitted over the top antenna in the front lobe is determined using Figure 2-1 and the number of whisper-shout steps transmitted by a given TCAS II M aircraft.

OUTPUT: Highest whisper-shout power transmitted.

VARIABLES OF INTEREST

Description	Variable Name
Highest transmitted power	HIATPW
Number of whisper-shout levels sent	NWSL

PROCESS:

1. Use of number of whisper-shout levels sent to find the highest priority level sent.
2. **IF** the highest priority sent $\geq$ 79, **THEN**

   Find the highest power level sent on the top antenna.
3. **ELSE**

   Find the highest power level (in dBm) sent on the bottom antenna.
4. **END IF**
5. Convert the power level to watts.
6. Return.

Called by: INTLI

Subroutines called: None.

3.3.23 Subroutine: STATS

PURPOSE: To write out the TCAS II M parameters of interest after each second.

INPUTS: All common variables of interest.

PROCEDURE: At the end of each second, the TCAS II M variables of interest are written for each TCAS II M aircraft. The mean values of the variables of interest are computed by averaging over all TCAS II M aircraft in the environment.

OUTPUT: TCAS II M statistics.

VARIABLES OF INTEREST

Description	Variable Name
Aircraft ID	I111
TCAS II M ID	II
Probability of Reply	PREP
Number of fruit received	FRUIT
Number of TCAS II M detected by squitter	NOW
Mode S interrogation rate	DRATE
Number of Mode S acquisition interrogators	ACQSUM
Number of Mode S roll-call interrogators	ROLSUM
Number of Mode S misaddresses received	MIS
Number of aircraft in the track file	NACTRIC
Number of aircraft in the null state	NULL
Number of aircraft in the squitter state	MSQ
Number of aircraft in the acquisition state	MAQ
Number of aircraft in the roll-call state	MROL
Number of aircraft in the dormant state	MDOR
Number of whisper-shout steps sent	NWSL
Total Mode S and ATCRBS power sent	TPOW
Maximum Mode S power transmitted	MAXMSP

Mode S freeze counter IRESET

Interference limiting condition indicator IRETRN

PROCESS:

1. **IF** First TCAS II M aircraft in file, **THEN**
   a. Write heading.
   b. Clear array containing averaged values.
2. **END IF**
3. Convert specific real-valued variables to integer format.
4. Write out variables of interest.
5. Compute the sum of each variable of interest over all TCAS II M aircraft.
6. **IF** Last TCAS II M aircraft in file, **THEN**
   a. Compute the average for the variables of interest.
   b. Write the average value for the variables of interest.
7. **END IF**
8. Return.

Called By: CIRCAS

Subroutines called: None.

3.3.24 Subroutine: **FILES**

PURPOSE: To create an output disk file to be used as input data to the DABS/ATCRBS/AIMS PPM which will determine net effects of deploying TCAS systems in the environment.

INPUTS: Total interrogations received by each TCAS II M, number of aircraft, number of whisper-shout levels each TCAS II M-equipped aircraft uses, Mode S addresses and misaddresses, ATCRBS and Mode S interrogations and suppressions due to TCAS II M, and TCAS I interrogations at each aircraft.

PROCEDURE: In a loop over all TCAS II M aircraft, the total amount of mutual suppression time (due to receiver turn-off during interrogations) is calculated. The following quantities for each aircraft are output to a disk file: Mode S addresses and misaddresses, Mode S and ATCRBS interrogations and suppressions due to TCAS II M emissions, TCAS I interrogations, and TCAS II M mutual suppression time.

OUTPUTS: Mode S addresses and misaddresses, ATCRBS and Mode S interrogations and suppressions due to TCAS II M emissions, TCAS I interrogations, and total amount of TCAS II M suppression time.

VARIABLES OF INTEREST

Description	Variable Name
Total TCAS II M suppression time	AMTSUP
Mode S misaddresses	MIS
Mode S addresses	ADRESS
ATCRBS interrogations	IATIN
ATCRBS suppressions	IATSU
Mode S interrogations	IDABN
Mode S suppressions	IDABS
TCAS I interrogations	ATCRAT

Total interrogations received by TCAS II M	DRATE
Number of aircraft	NAC
Number of whisper-shout levels used by each TCAS II M	NWSL

PROCESS:

1. Set TCAS II M counter to zero.
2. **LOOP** over all aircraft.
   - A. **IF** TCAS II M-equipped aircraft **THEN**
     1. Increment TCAS II M counter.
     2. Calculate total TCAS II M suppression time in microseconds using above counter to locate correct TCAS II M in arrays (Suppression time = 60.0 times the number of whisper-shout steps TCAS II M is using + 100.0 times total interrogations received by TCAS II M transponder).
   - B. **ELSE**
     1. Set total TCAS II M suppression time to zero.
   - C. **END IF**
   - D. Write the following quantities to output file: Mode S addresses and misaddresses, Mode S and ATCRBS interrogations and suppressions due to TCAS II M emissions, TCAS I interrogations, and total TCAS II M suppression time.
   - 3. **END LOOP**
   - 4. Return.

Called by: CIRCAS

Subroutines called: None.

APPENDIX A

TCAS SEM DATA DICTIONARY

The following data dictionary describes each common variable for understanding the code.

VARIABLE NAME	NUMBER OF ELEMENTS	TYPE	LABELED COMMON BLOCK	SUBROUTINES	UNITS	DESCRIPTION
ACQSUM	1	REAL	ROLACQ	DISMOD,INT,STATS	-	MODE S INTERROGATION COUNTER
ADRESS	NUAIR[a]	REAL	SETA	DISINT,FILES,INT	-	MODE S ADDRESSES
AMSP	83	REAL	ILMS	DISINT,DISMOD, INIT,INTLI,PRESET, STATS,TCSMOT	watts	ADJUSTED TRANSMISSION POWER FOR TCAS II M AIRCRAFT
ANTBOT	19	REAL	ANTT	ANTGAN,INIT,TCAS1	dBi	TRANSMITTING TCAS AIRCRAFT BOTTOM ANTENNA PATTERN
ANTTOP	19	REAL	ANTT	ANTGAN,INIT,TCAS1	dBi	TRANSMITTING TCAS AIRCRAFT TOP ANTENNA PATTERN
ATCRAT	NUAIR	REAL	TCRAT1	FILES,INIT,STATS, TCAS1	INTERROGATIONS/ SECOND	TCAS I INTERROGATIONS AT EACH AIRCRAFT PER SECOND
ATSUMP	0:83	REAL	ILMS	ASPINT,INTLI	WATTS	TOTAL POWER RADIATED WITH N WHISPER-SHOUT LEVELS
AZPAT	36	REAL	ANTENN	ATMOD,INIT	dB	TCAS II M TOP ANTENNA SUM PATTERNS
BEARTX	1	REAL	BBBEAR	BEAR,LOAD	RADIANS	HORIZONTAL ANGLE BETWEEN TCAS II M AND VICTIM AIRCRAFT
DIFPAT	36	REAL	ANTENN	ATMOD,INIT	dB	TCAS II M TOP ANTENNA DIFFERENCE PATTERNS
DINTRT	NUAIR	REAL	ONT	DISINT,DISMOD, INIT	ADDRESSES/ SECOND	MODE S ADDRESSED RATE TO EACH AIRCRAFT (PER SECOND)
DIST	1	REAL	BBBEAR	BEAR,LOAD,TCAS1	NAUTICAL MILES	DISTANCE BETWEEN TCAS II M AND VICTIM AIRCRAFT
DORSUM	1	REAL	ROLACQ	DISMOD,INIT,STATS	-	NUMBER OF VICTIM AIRCRAFT TCAS II M OF INTEREST HAS IN DORMANCY STATE
DRATE	83	REAL	ATE	DISINT,DISMOD, FILES,STATS,TCSMOT	INTERROGATIONS/ SECOND	TOTAL INTERROGATIONS TRANSMITTED BY EACH TCAS II M (UPDATED ON A SECOND-BY-SECOND BASIS)

VARIABLE NAME	NUMBER OF ELEMENTS	TYPE	LABELED COMMON BLOCK	SUBROUTINES	UNITS	DESCRIPTION
FRUIT	83	REAL	FRUT	DISMOD, FRUITA INIT, STATS	-	FRUIT SEEN BY EACH TCAS II M AIRCRAFT
I111	83	INTEGER	TCDATA	ANTGAN, ATMOD, DISINT, DISMOD, FILES, FRUITA, INIT, INTLI, LOAD, PRESET, TCSMOT, TSQUIT, TSTART	-	TCAS II M POINTER FILE
IACTOT	NVAIR	INTEGER	TRAN	TSTART, TSQUIT	-	INVERSE TCAS II M POINTER
IADJIN	NUAIR	INTEGER	RATE	FRUITA, INIT, INPUT	INTERROGATIONS/ SECOND	INTERROGATION RATE FOR EACH AIRCRAFT DUE TO GROUND ATC (PER SECOND)
IADJSU	NUAIR	INTEGER	RATE	FRUITA, INIT, INPUT	SUPPRESSIONS/ SECOND	SUPPRESSION RATE FOR EACH AIRCRAFT DUE TO GROUND ATC (PER SECOND)
IATCR	1	INTEGER	DPLYMT	DISINT, INIT, INPUT	-	NUMBER OF ATCRBS AIRCRAFT IN DEPLOYMENT
IATIN	NUAIR	INTEGER	TCDATA	ATMOD, FRUITA, INIT, STATS	INTERROGATIONS/ SECOND	ATCRBS INTERROGA- TIONS DUE TO TCAS II M AIRCRAFT (PER SECOND)
IATSU	NUAIR	INTEGER	TCDATA	ATMCD, FRUITA, INIT, STATS	SUPRESSIONS/ SECOND	ATCRBS SUPPRESSIONS DUE TO TCAS II M AIRCRAFT (PER SECOND)
ICASFI	83, NUAIR	INTEGER, PACKED	CAS	ANTGAN, ATMOD, DISINT, DISMOD, FRUITA, LOAD, PRESET	-	INFORMATION ON VICTIM AIRCRAFT RELATIVE TO EACH TCAS II M AIRCRAFT:
					10X NAUTICAL MILES	SLANT RANGE-BITS(0:8)
					40* RADIANS	BEARING OF VICTIM AIRCRAFT RELATIVE TO THE HEADING OF THE TCAS II M AIRCRAFT, (BITS 9:16)
					10* dB	PROPAGATION PATH LOSS, (BITS 17:26)
					--	SECTOR IN WHICH VICTIM AIRCRAFT IS LOCATED, (BITS 27:33)
					--	VICTIM AIRCRAFT TYPE, SAME AS IJFILE(N,4), (BITS 34:35)

VARIABLE NAME	NUMBER OF ELEMENTS	TYPE	LABELED COMMON BLOCK	SUBROUTINES	UNITS	DESCRIPTION
IDAB	1	INTEGER	DPLYMT	INIT,INPUT, PRESET	-	NUMBER OF MODE 3 AIRCRAFT IN THE DEPLOYMENT
IDABN	NUAIR	INTEGER	TCDATA	ATMOD,FRUITA, INIT,STATS	INTERROGATIONS/ SECOND	MODE S INTERROGATIONS DUE TO TCAS II M EMISSIONS (PER SECOND)
IDABS	NUAIR	INTEGER	TCDATA	ATMOD,FRUITA, INIT,STATS	-	MODE S SUPPRESSIONS DUE TO TCAS II M EMISSIONS (PER SECOND)
II	1	INTEGER, INTEGER	CAS	ANTGAN,ATMOD, CIRCAS,DISINT, DISMOD,FRUITA, INTLI,TCSMOT, TSQUIT	-	TCAS II M AIRCRAFT IDENTITY
LJFILE	NUAIR, 8	INTEGER	CAS	ANTGAN,ATMOD, DISINT,DISMOD, FILES,FRUITA, INPUT,LOAD,STATS, TCAS1,TSTART	COL. 4: - COL. 8: dBm	TYPE OF EACH AIRCRAFT ANTENNA COUPLINGS BETWEEN TCAS II M AND ALL OTHER AIRCRAFT
IPRB	15	INTEGER	WSHOUT	ATMOD,INIT,	-	TCAS II M BACK ANTENNA WHISPER-SHOUT POWER INTERFERENCE-LIMITING PRIORITY SEQUENCE
IPRBOT	4	INTEGER	WSHOUT	ATMOD,INIT,	-	TCAS II M BOTTOM ANTENNA WHISPER-SHOUT POWER INTERFERENCE LIMITING PRIORITY SEQUENCY
IPRF	24	INTEGER	WSHOUT	ATMOD,INIT,	-	TCAS II M FRONT ANTENNA WHISPER-SHOUT POWER INTERFERENCE LIMITING PRIORITY SEQUENCE
IPRS	40	INTEGER	WSHOUT	ATMOD,INIT,	-	TCAS II M SIDE ANTENNA WHISPER-SHOUT POWER INTERFERENCE LIMITING PRIORITY SEQUENCE
IRESET	83	INTEGER	ILMS	INIT,INTLI	SECONDS	16-SECOND FREEZE COUNTER
IRETRN	1	INTEGER	ILMS	INTLI,STATS	-	INTERFERENCE LIMITING CONDITION INDICATOR

VARIABLE NAME	NUMBER OF ELEMENTS	TYPE	LABELED COMMON BLOCK	SUBROUTINES	UNITS	DESCRIPTION
IROL	10	INTEGER	RCACQ	DISMOD, INIT	INTERROGATIONS	MAXIMUM NUMBER OF INTERROGATIONS ALLOWED PER SECOND TO AN AIRCRAFT IN THE ROLL-CALL STATE
ITCA	1	INTEGER	DPLYMT	INIT, INPUT, PRESET	-	NUMBER OF TCAS II M AIRCRAFT
ITIME	1	INTEGER	TEMP	ATMOD, CIRCAS, DISINT, DISMOD, FILES, INIT, INTL1, LOAD, STATS, TCSMOT, TSQUIT	SECONDS	SIMULATION CLOCK (ELAPSED TIME IN SIMULATION)
ITLAST	83,83	INTEGER, PACKED	TRAN	INIT, TSQUIT	- SECONDS	INDICATED WHETHER A TCAS II M AIRCRAFT HAS BEEN DETECTED BY SQUITTER (BIT 0) TIME OF LAST RECEIVED SQUITTER (BITS 1:10)
ITOB	100	INTEGER	STNT	DISINT, DISMOD, INIT	-	INDICATES WHETHER TCAS II M USED TOP OR BOTTOM ANTENNA TO TRANSMIT
ITRACK	83,500	INTEGER, INTEGER	SURV	DISMOD, INIT, LOAD, PRESET	- - - - - - -	MODE S TRACK FILE VICTIM IDENTIFICATION, BITS (0:9) ICLOCK, (BITS 10:17) ISTATE, (BITS 18:21) ITRIAL, (BITS 22:24) KSCAN, (BITS 25:28) IBOT, (BITS 29)
ITRIL1	6	INTEGER	RCACQ	DISMOD, INIT	INTERROGATIONS	MAXIMUM NUMBER OF INTERROGATIONS ALLOWED PER SCAN DURING FIRST ACQUISITION TRIAL
ITRIL2	6	INTEGER	RCACQ	DISMOD, INIT	INTERROGATIONS	MAXIMUM NUMBER OF INTERROGATIONS ALLOWED PER SCAN DURING SECOND ACQUISITION TRIAL
ITRIL3	6	INTEGER	RCACQ	DISMOD, INIT	INTERROGATIONS	MAXIMUM NUMBER OF INTERROGATIONS ALLOWED PER SCAN DURING THIRD ACQUISITION TRIAL
ITRIL4	6	INTEGER	RCACQ	DISMOD, INIT	INTERROGATIONS	MAXIMUM NUMBER OF INTERROGATIONS ALLOWED PER SCAN DURING FOURTH ACQUISITION TRIAL

VARIABLE NAME	NUMBER OF ELEMENTS	TYPE	LABELED COMMON BLOCK	SUBROUTINES	UNITS	DESCRIPTION
JSENS	NUAIR	INTEGER	SENS	ATMOD,DISINT,DISMOD FILES,FRUITA,INIT, INTLI,PRESET, TCAS1, TRANSP	dBm	SENSITIVITY LEVELS FOR ALL AIRCRAFT
JTRANS	NUAIR	INTEGER	TRAX	ATMOD,DISINT,DISMOD FRUITA,INIT,INTLI, PRESET,STATS,TCSMOT, TRANSP	MILLIWATTS	TRANSMISSION POWER LEVELS FOR ALL AIRCRAFT
K	1	INTEGER	SINT	DISMOD,INIT,TSQUIT	-	VICTIM AIRCRAFT IDENTITY
LPLUS	1	INTEGER	SINT	DISINT,DISMOD,INIT	INTERROGATIONS	NUMBER OF TCAS II M TRANSMISSIONS (PER SECOND)
MAQ	1	INTEGER	ROLACQ	DISMOD,INIT,STATS	-	ACQUISTION COUNTER
MDOR	1	INTEGER	ROLACQ	DISMOD,INIT,STATS	-	DORMANCY COUNTER
MIS	NUAIR	INTEGER	MISAD	DISINT,DISMOD, FILES,FRUITA,INIT, STATS	MISADDRESSES/ SECOND	MODE S MISADRESSES (PER SECOND)
MROL	1	INTEGER	ROLACQ	DISMOD,INIT,STATS	-	ROLL CALL COUNTER
MSQ	1	INTEGER	ROLACQ	DISMOD,INIT,STATS	-	SQUITTER STATE COUNTER
NAC	1	INTEGER	CAS	ANTGAN,ATMOD, DISINT,FILES,FRUITA INPUT,LOAD,STATS, TCAS1,TSTART	-	AIRCRAFT COUNTER
NOW	83	INTEGER	SMOOTH	DISMOD,INIT,INTLI, STATS,TSQUIT	-	NUMBER OF TCAS II M DETECTED BY SQUITTER, PER SECOND
NUAIR	1	INTEGER PARAMETER		ANTGAN,ATMOD, CIRCAS,DISINT,DISMOD, FILES,FRUITA,INIT, INPUT,INTLI,LOAD, NEWTHS,PRESET,STATS, TCAS1,TCSMOT,TRANSP, TSQUIT,TSTART,WSCONT, WSPOWE	-	NUMBER OF AIRCRAFT IN DEPLOYMENT
NULL	1	INTEGER	ROLACQ	DISMOD,INIT,STATS	-	NULL STATE COUNTER
NUMTCA	1	INTEGER	TCAA	CIRCAS,DISINT, DISMOD,FILES,INIT, LOAD,PRESET,STATS, TSQUIT,TSTART,TCSMOT	-	NUMBER OF TCAS II M AIRCRAFT

VARIABLE NAME	NUMBER OF ELEMENTS	TYPE	LABELED COMMON BLOCK	SUBROUTINES	UNITS	DESCRIPTION
NWSL	83	INTEGER	ILWS	DWRT,INTLI,ATMGO	-	NUMBER OF W-S LEVELS EACH TCAS II M USES
PASBOT	19	REAL	ANTO	ANTGAN,INIT,TCAS1	dBi	RECEIVING AIRCRAFT BOTTOM ANTENNA PATTERN
PASTOP	19	REAL	ANTO	ANTGAN,INIT,TCAS1	dBi	RECEIVING AIRCRAFT TOP ANTENNA PATTERN
PREP	NUAIR	REAL	TPREPL	FRUITA,INIT,TSQUIT	-	PROBABILITY OF REPLY FOR EACH AIRCRAFT
RLAT	1	REAL	BBBEAR	BEAR,LOAD,TCAS1	RADIANS	VICTIM AIRCRAFT LATITUDE
RLON	1	REAL	BBBEAR	BEAR,LOAD,TCAS1	RADIANS	VICTIM AIRCRAFT LONGITUDE
ROLSUM	1	REAL	ROLACQ	DISMOD,INIT,STATS	-	NUMBER OF AIRCRAFT IN ROLL-CALL STATE
SESIT	83	REAL	ADJSEN	DISMOD,INTLI,PRESET	dBm	ADJUSTED TCAS II M SENSITIVITY LEVELS
TCST	83	REAL	TRAN	INIT,TSQUIT,TSTART	SECONDS	TCAS II M SQUITTER START TIME
TIS	83	REAL	SMOOTH	INIT,INTLI,TCSMOT	MILLIWATTS	SMOOTHED EMISSION POWERS
TJFILE	NUAIR,8	REAL, REAL	CAS	ANTGAN,DISMOD,INPUT LOAD,PRESET,TCAS1	COL.1: RADIANS 2: RADIANS 3: FEET 5: NMI/S 6: NMI/S 7: FT/S	LATITUDE OF AIRCRAFT LONGITUDE OF AIRCRAFT ALTITUDE LONGITUDINAL VELOCITY (NORTH = +) LATITUDINAL VELOCITY (WEST = +) UPWARD VELOCITY
TLAT	1	REAL	BBBEAR	BEAR,LOAD,TCAS1	RADIANS	TCAS II M LATITUDE
TLON	1	REAL	BBBEAR	BEAR,LOAD,TCAS1	RADIANS	TCAS II M LONGITUDE
TPOW	1	REAL	LEVEL	INIT,INTLI,STATS	dB	TOTAL WHISPER-SHOUT POWER RADIATED
TPS	83	REAL	SMOOTH	INIT,INTLI,TCSMOT	-	SMOOTHED INTERROGATION RATES (PER SECOND)
UPRATE	NUAIR	REAL	ONT	DISINT,DISMOD,INIT	-	TOTAL NUMBER OF INTERROGATIONS RECEIVED BY EACH AIRCRAFT

[a]NUAIR is the number of aircraft in the deployment.

APPENDIX B

TCAS SEM LISTING

The following is a compiled ASCII FORTRAN listing of the TCAS SEM. The program segments appear in alphabetical order.

```
***       ANTGAN       ***

@FTN,S B.ANTGAN,ANTGAN
FTN 11R1      02/27/85-16:35(36,)
                 SUBROUTINE ANTGAN
            C
            C    THE PURPOSE OF THIS SUBROUTINE IS TO STORF ELEVATION ANTENNA PATTERNS
            C       BETWEEN TCAS AND VICTIM AIRCRAFT.
            C
            C    ****************INPUTS / OUTPUTS  *********************************
            C    COMMON BLOCKS /    VARIABLES
            C                       INPUTS  OUTPUTS      DESCRIPTIONS
            C
            C          ANTO   /                          TCAS II M RECEIVING ANTENNA PATTERNS:
            C                 / PASBOT                     BOTTOM ANTENNA
            C                 / PASTOP                     TOP ANTENNA
            C          ANTT   /                          TCAS IIM TRANSMITTING ANTENNA PATTERNS:
            C                 / ANTBOT                     BOTTOM ANTENNA
            C                 / ANTTOP                     TOP ANTENNA
            C          CAS    / ICASFI                   TCAS II M ENVIRONMENTAL FILE
            C                 / II                       TCAS II M IDENTITY
            C                          IJFILE            ANTENNA PATTERNS BETWEEN TCAS II M/VTM
            C                 . NAC                      NUMBER OF AIRCRAFT IN DEPLOYMENT
            C          TCDATA / I111                     TCAS II M POINTER FILE
            C
                 INCLUDE RESTART,LIST
                 PARAMETER (NUAIR = 328)
            C
            C    THE LOGICAL VARIABLE PRINT, WHEN FALSE, WILL SUPPRESS ALL WRITE
            C    STATEMENTS IN THE MODEL.
            C
                 LOGICAL PRINT
                 DIMENSION TJFILE(NUAIR,8), IJFILE(NUAIR,8), ICASFI(83,NUAIR,1)
                 COMMON /TCDATA/ I111(83), DENS(83),
                ?  IATIN(NUAIR), IATSU(NUAIR), IDABN(NUAIR), IDABS(NUAIR)
                 EQUIVALENCE (TJFILE,IJFILE)
                 COMMON /CAS/ ICASFI, TJFILE, NAC, II, PRINT
                 COMMON/ANTT/ANTTOP(19),ANTBOT(19)
                 COMMON/ANTO/PASTOP(19),PASBOT(19)
                 PARAMETER (R2D = 57.296)            @ CONVERTS ANGLES FROM RADIANS
            C                                          TO DEGREES
                 DEFINE FLD(I,J,K) = BITS(K,I+1,J)
            C
            C    HAVE A TCAS AIRCRAFT.
            C
                 IH = I111(II)
                 ALT1 = TJFILE(IH,3)/6076.0          @ ALTITUDE OF TCAS A/C IN
            C                                          NAUTICAL MILES
                 DO 201 K=1,NAC                      @ COMPUTE ANTENNA COUPLING
            C                                          (ELEVATION PATTERNS)
 1                  IF(IH.EQ.K)GO TO 201             @ DON'T DO COUPLING CALCULATIONS
 1          C                                          OF A/C WITH ITSFLF
 1                  IF(ICASFI(II,K,1).EQ.0)GO TO 201 @ SKIP IF A/C OUT OF RANGE
 1                  ALT2 = TJFILE(K,3)/6076.0        @ ALTITUDE OF VICTIM A/C
 1          C                                          IN NAUTICAL MILES
 1                  C = FLD(00,09,ICASFI(II,K,1))/10.@ SLANT RANGE BETWEEN TCAS IIM & VICTM
 1                  B = (ALT1 - ALT2)                @ DIFFERENCE IN ALTITUDES IN
 1          C                                          NAUTICAL MILES
 1                  DIST = SQRT(C*C - B*B)           @ HORIZONTAL DISTANCE BETWEEN A/C
 1                  ARG = B/DIST
 1                  THET = (ATAN(ARG))*R2D           @ VERTICAL ANGLE (DEGREES)
```

```
***     ANTGAN      ***

1     C                                                  SEPARATING A/C
1              THETA1 = ABS((THET+90.)/10.)
1              ITH1 = THETA1 + 1
1              THETA2 = ABS((THET - 90.)/10.)
1              ITH2 = THETA2 + 1                  @ COMPUTE ANTENNA COUPLINGS.
1              GN1 = ANTTOP(ITH1) + ((THETA1+1) @ TCAS IIM TOP ANTENNA GAIN
1          ?   - FLOAT(ITH1))*(ANTTOP(ITH1+1) - ANTTOP(ITH1))
1              GN2 = PASBOT(ITH2) + ((THETA2+1) @ VICTIM BOTTOM ANTENNA GAIN
1          ?   - FLOAT(ITH2))*(PASBOT(ITH2+1) - PASBOT(ITH2))
1              GN3 = ANTBOT(ITH1) + ((THETA1+1) @ TCAS IIM BOTTOM ANTENNA GAIN
1          ?   - FLOAT(ITH1))*(ANTBOT(ITH1+1) - ANTBOT(ITH1))
1              GN4 = PASTOP(ITH2) + ((THETA2+1) @ VICTIM TOP ANTENNA GAIN
1          ?   - FLOAT(ITH2))*(PASTOP(ITH2+1) - PASTOP(ITH2))
1              P = FLD(17,10,ICASFI(II,K,1))    @ TCAS IIM POWER
1     C
1     C STORE COUTPLINGS AS INTEGER VALUES.  THE SYSTEM FUNCTION, IFIX, BELOW,
1     C CONVERTS THE FLOATING POINT NUMBERS TO INTEGERS FOR STORAGE.
1     C
1              FLD(00,09,IJFILE(K,8)) = IFIX(GN1*10.)
1              FLD(09,09,IJFILE(K,8)) = IFIX(GN2*10.)
1              FLD(18,09,IJFILE(K,8)) = IFIX(GN3*10.)
1              FLD(27,09,IJFILE(K,8)) = IFIX(GN4*10.)
1         201 CONTINUE
              RETURN
              END

END FTN 247 IBANK 67 DBANK 31405 COMMON
```

```
***       ASPINT        ***

@FTN,S A.ASPINT,A.ASPINT
FTN 11R11R1A 05/30/85-13:14(4,)
                SUBROUTINE ASPINT                   @ ATCRBS SUM POWER INITIALIZE
          *
          * THIS SUBROUTINE INITIALIZE THE ARRAY CONTAINING THE TOTAL RADIATE POWER
          * FROM N W-S POWER LEVELS IN WATTS
          *
          *  **********************  INPUTS / OUTPUTS ***********************
          *
          *    COMMON BLOCKS /    VARIABLES
          *                     INPUTS     OUTPUTS    DESCRIPTION
          *
          *        ILMS     /            ATSUMP     TOTAL RADIATED FROM N W-S LEVELS
          *
                INCLUDE ILMS
          *
                DEFINE SUM(N) = (ONEDB**N - 1)/(ONEDB -1)
                DEFINE SUMB(N) = (TWODB**N - 1)/(TWODB -1)
          *
                ONEDB = 10.**(.1)                        @ DEFINE 1 DB
                TWODB = 10.**(.2)                        @ DEFINE 2 DB
                PTOPLO = 10.**(( 26. -30.)/10.)          @ 26 DBM -30 DB TO GET WATTS
                PBOTLO = 10.**(( 30. -30.)/10.)          @ 30 DBM -30 DB TO GET WATTS
                ATSUMP(0) = 0.
          *
          *        LOOP OVER ALL 83 W-S LEVELS
          *
                DO 10 IPRI=1,83
          *
          *          DETERMINE # OF W-S LEVELS SENT ON THE TOP (FRONT, 2 SIDES, AND BACK)
          *          AND BOTTOM ANTENNAS
          *
1                  IF( IPRI .LE. 63) THEN
2                     NFRNT  = 24 - (IPRI + 2)/4
2                     NRSIDE = 20 - (IPRI + 1)/4
2                     NLSIDE = 20 - (IPRI)/4
2                     NBACK  = 15 - (IPRI - 1)/4
2                     NBOT   = 4
2                  ELSE IF( IPRI .LE. 75) THEN
2                     NFRNT  = 29 - (IPRI + 1)/3
2                     NRSIDE = 25 - (IPRI)/3
2                     NLSIDE = 25 - (IPRI - 1)/3
2                     NBACK  = 0
2                     NBOT   = 4
2                  ELSE IF( IPRI .LE. 80) THEN
2                     NFRNT  = 80 - IPRI
2                     NRSIDE = 0
2                     NLSIDE = 0
2                     NBACK  = 0
2                     NBOT   = 4
2                  ELSE
2                     NFRNT  = 0
2                     NRSIDE = 0
2                     NLSIDE = 0
2                     NBACK  = 0
2                     NBOT   = 84 -IPRI
2                  END IF
2         *
2         *           COMPUTE ATSUMP IN WATTS USING THE PROPERTIES OF A GEOMETERIC PROG
```

```
***       ASPINI        ***

 2           *
 1                   ATSUMP(64-IPRI) = PTOPLO*( SUM(NFRNT) + SUM(NRSIDE) +
 1                 2   SUM(NLSIDE)  + SUM(NBACK) ) + PBOTLO*( SUMB(NBOT) )
 1           *
 1           10      CONTINUE
                   RETURN
                   END

END FTN 177 IBANK 47 DBANK 335 COMMON

@HDG,P  ***        ANTGAN        ***
```

```
***       ATMOD       ***

@FTN,S A.ATMOD,A.ATMOD
FTN 11R1 05/30/85-13:14(20,)
              SUBROUTINE ATMOD
      C
      C       THIS SUBROUTINE DETERMINES THE EFFECTS OF TCAS WHISPER - SHOUT
      C          INTERROGATIONS AT ALL AIRCRAFT.
      C
      C      *****************  INPUTS / OUTPUTS  ***************************************
      C
      C      COMMON BLOCKS /     VARIABLES
      C                        INPUTS   OUTPUTS    DESCRIPTION
      C
      C             ANTENN / AZPAT                 SUM PATTERNS OF TCAS II M TOP ANTENNAS
      C                      DIFPAT                DIFFERENCE PATTERNS OF TCAS II M BOTTOM
      C                                              ANTENNAS
      C             CAS    / ICASFI                TCAS II M ENVIRONMENTAL FILE
      C                      II                    TCAS II M IDENTITY
      C                      IJFILE                ANTENNA COUPLINGS BETWEEN TCAS AND VCTM
      C                      NAC                   NUMBER OF AIRCRAFT IN DEPLOYMENT
      C             SENS   / JSENS                 SENSITIVITY LEVEL OF ALL AIRCRAFT
      C             TCDATA / I111                  TCAS II M POINTER
      C                      IATIN     IATIN       TCAS II M INTERROGATIONS TO ATCRBS
      C                      IATSU     IATSU       TCAS II M-PRODUCED ATCRBS SUPPRESSIONS
      C                      IDABN     IDABN       TCAS II M INTERROGATIONS TO MODE S
      C                      IDABS     IDABS       TCAS II M-PRODUCED MODE S SUPPRESSIONS
      C             TEMP   / ITIME                 ELAPSED TIME
      C             TRAX   / JTRANS                TRANSMISSION POWER LEVELS OF ALL A/C
      C             ILMS   / NWSL                  # OF W-S LEVELS SENT
      C             WSHOUT / IPRB                  ANTENNA PATTERNS:  BACK ANTENNA
      C                      IPRBO                                    BOTTOM ANTENNA
      C                      IPRF                                     FRONT ANTENNA
      C                      IPRS                                     SIDE ANTENNAS
      C
      C
              INCLUDE RESTART,LIST
              PARAMETER (NUAIR = 743)
      C
      C       THE LOGICAL VARIABLE PRINT, WHEN FALSE, WILL SUPPRESS ALL WRITE
      C       STATEMENTS IN THE MODEL.
      C
              LOGICAL PDISMO,PINTLI,PTCSMT,PATMOD,PDISIN,PFILES,PFRUIT,PSTATS
              COMMON /PRTBL/ PDISMO,PINTLI,PTCSMT,PATMOD,PDISIN,PFILES,PFRUIT,
             2  PSTATS
      *
              DIMENSION TJFILE(NUAIR,8), IJFILE(NUAIR,8), ICASFI(83,NUAIR,1)
              COMMON /TCDATA/ I111(33), DENS(83),
             ?   IATIN(NUAIR), IATSU(NUAIR), IDABN(NUAIR), IDABS(NUAIR)
              EQUIVALENCE (TJFILE,IJFILE)
              COMMON /CAS/ ICASFI, TJFILE, NAC, II, PRINT
              INCLUDE ANTENN,LIST
                COMMON /ANTENN/ AZPAT(36), DIFPAT(36)
              INCLUDE ILMS,LIST
                COMMON /ILMS/ NWSL(83), AMSP(83), IRESET(83), ATSUMP(0:83),
             2    IRETRN, TPOW
              INCLUDE WSHOUT,LIST
                COMMON /WSHOUT/ IPRF(24), IPRS(40), IPRB(15), IPRBOT(4),
             1    IPOWF(24), IPOWS(41), IPOWB(15), IPOWBO(4)
              INCLUDE TEMP,LIST
                COMMON /TEMP/ ITIME
```

```
***      ATMOD       ***

              INCLUDE TRAX,LIST
                COMMON /TRAX/ JTRANS(NUAIR)
              INCLUDE SENS,LIST
                COMMON /SENS/ JSENS(NUAIR)
              INTEGER SA
              DIMENSION NUM(5)
              DEFINE FLD (I,J,K) = BITS(K, I + 1, J)
              DATA (NUM(I),I = 1, 5) /4, 24, 20, 15, 20/
         C
              SA = I111(II)
              DO 200  IJ = 1, NAC
 1               IF (ICASFI(II,IJ,1).EQ.0) GO TO 200 @ SKIP IF A/C IS OUT OF RANGE
 1               KTYP = FLD(34,2,ICASFI(II,IJ,1))
 1       C
 1       C    BR IS RELATIVE BEARING BETWEEN TCAS II M AND VICTIM AIRCRAFT
 1       C    THE FACTOR OF 57.296 CONVERTS THE ANGLE FROM RADIANS TO DEGREES.
 1               BR = (FLD(9,8,ICASFI(II,IJ,1))/40.)*57.296
 1               SEN = JSENS(IJ)                         @ SENSITIVITY OF VICTIM A/C
 1       C
 1       C    ANTENNA COUPLINGS (ELEVATION PATTERN)
 1               IGN1 = (FLD(00,09,IJFILE(IJ,8))*(2**27))
 1               IGN1 = IGN1/(2**27)
 1               IGN2 = (FLD(09,09,IJFILE(IJ,8))*(2**27))
 1               IGN2 = IGN2/(2**27)
 1               IGN3 = (FLD(18,09,IJFILE(IJ,8))*(2**27))
 1               IGN3 = IGN3/(2**27)
 1               IGN4 = (FLD(27,09,IJFILE(IJ,8))*(2**27))
 1               IGN4 = IGN4/(2**27)
 1               GN1 = FLOAT(IGN1)/10.+4.7+6.0-4.1    @ ADJUSTMENT OF TCAS TOP ANTENNA
 1               GN2 = FLOAT(IGN2)/10.
 1               GN3 = FLOAT(IGN3)/10.+4.7+6.0-4.1    @ ADJUSTMENT OF TCAS BOTTOM ANTENNA
 1               GN4 = FLOAT(IGN4) / 10.
 1               IPOW = FLD(17,10,ICASFI(II,IJ,1))    @ FREE SPACE POWER BETWEEN TCAS IIM
 1       C                                              AND VICTIM AIRCRAFT.
 1               POW = IPOW
 1               ATRANS = JTRANS(SA)/1 000 000.
 1       C     ADJUSTED POWER:
 1               POW = -(POW/10.) + 10.*ALOG10(ATRANS) - 2.796 - 3.0
 1               IF (POW.LT.-84.) GO TO 200
 1               GV = GN2
 1               IF ((GN4.GT.GN2).AND.(KTYP.NE.0)) GV = GN4
 1               MSEC = INT(BR / 10. + 0.5) + 1       @ INTEGER OF SECTOR DEFINED BETWEEN
 1       C                                              TCAS II M AND VICTIM AIRCRAFT.
 1               DO 1007 KP = 1, 5                    @ DEFINES 90 DEGREE CUTS:
 1       C                                              KP = 1 IS BOTTOM FRONT ANTENNA
 1       C                                                   2 IS TOP FRONT ANTENNA
 1       C                                                   3 IS RIGHT SIDE
 1       C                                                   4 IS BACK
 1       C                                                   5 IS LEFT SIDE
 2                  IF (MSEC.GT.36) MSEC = 36
 2                  IF (MSEC.LT.0) MSEC= MSEC + 36
 2                  IF (MSEC.EQ.0) MSEC = 1
 2                  SHIFT = -AZPAT(MSEC)              @ SUM PATTERN - GIVEN SECTOR.
 2                  DIFIFT = -DIFPAT(MSEC)            @ DIFFERENCE PATTERN - GIVEN SECTOR
 2                  IF (KP.NE.1) MSEC = MSEC - 9      @ MOVE 90 DEGREE SECTOR.
 2                  ISKIP = 3                         @ 3 DB FOR W-S SEQUENCE.
 2                  DO 111  IATT = 1, NUM(KP)
 3                     IF (KP.EQ.1) THEN
 4                        IMAX = IPRBOT (IATT)
```

```
***      ATMOD      ***
4                  ELSE IF (KP.EQ.2) THEN
4                     IMAX = IPRF (IATT)
4                  ELSE IF (KP.EQ.3) THEN
4                     IMAX = IPRS (IATT*2)
4                  ELSE IF (KP.EQ.4) THEN
4                     IMAX = IPRB (IATT)
4                  ELSE
4                     IMAX = IPRS (IATT*2 + 1)
4                  END IF
4     C
4     C        CHECK TO SEE IF NUMBER OF LEVELS CUT EXCEEDS PRIORITY LEVEL:
3                  IF (IMAX .LE. 83-NWSL(II)) GO TO 111
3                  ATTENI = 24 - IATT              @ TOTAL ATTENTUATION.
3                  PWRI = POW - ATTENI             @ INTERROGATION POWER.
3                  PWRS = PWRI - 1*ISKIP           @ SUPPRESSION POWER.
3                  IF (IATT.EQ.1) PWRS = -100.     @ FIRST INT. SUPPRESSION IS MADE
3     C                                              AT A LOWER POWER LEVEL
3                  ISKIP = ISKIP - 1               @ SUPPRESSION DOWN COUNTER.
3                  IF (ISKIP.LT.1) ISKIP = 3
3                  IF ((ISKIP.LE.1).AND.(KTYP.EQ.0)) ISKIP = 3
3                  GNCOUP = GN1 + GV               @ ANTENNA COUPLINGS BETWEEN
3                  IF (KP.EQ.1) GNCOUP = GN3+GV    @   TCAS II M AND VICTIM AIRCRAFT
3                  SMPWRI = PWRI +SHIFT +GNCOUP    @ INTERROGATION SUM POWER.
3                  DFPWRI = PWRI +DIFIFT +GNCOUP   @ INTERROGATION DIFFERENCE POWER
3                  SMPWRS = PWRS +SHIFT + GNCOUP   @ SUPPRESSION SUM POWER.
3                  OMPWRI = 0.
3                  IF (KP.EQ.1) THEN
4                     OMPWRI = POW + GNCOUP        @ INTERROGATIONS ON OMNI.
4                     IF (IATT.EQ.1) THEN          @ ADJUST INTERROGATION POWER
5                        OMPWRI = OMPWRI - 19
5                        IF (KTYP.EQ.0) THEN
6                           OMPWRS = -110
6                        ELSE
6                           OMPWRS = -100
6                        END IF
5                     ELSE IF (IATT.EQ.2)THEN
5                        OMPWRI = OMPWRI - 17
5                        OMPWRS = OMPWRI - 3.0
5                     ELSE IF (IATT.EQ.3) THEN
5                        OMPWRI = OMPWRI - 15
5                        OMPWRS = OMPWRI - 3.0
5                     ELSE IF (IATT.EQ.4) THEN
5                        OMPWRI = OMPWRI - 13
5                        OMPWRS = OMPWRI - 3.0
5                     END IF
4                     DFPWRI = 0.
4                     SMPWRI = 0.
4                     SMPWRS = 0.
4     C
4              IF ( PATMOD)
4           1  WRITE(*,999) IJ,BR,KP,MSEC,OMPWRI,OMPWRS,SEN
4        999   FORMAT(' ATMOD: FMT 999 ',I3,2X,F10.3,5X,2(I5,5X),3(F10.3,5X))
4                     IF (OMPWRS.GE.SEN) THEN      @ COUNT SUPPRESSIONS
5                        IF (KTYP.NE.0) THEN
6                           IDABS(IJ) = IDABS(IJ) + 1
6                        ELSE
6                           IATSU(IJ) = IATSU(IJ) + 1
6                        END IF
5                     ELSE IF (OMPWRI.GE.SEN) THEN
```

```
***       ATMOD       ***

 5                         IF (KTYP .EQ.0) THEN     @ COUNT INTERROGATIONS
 6                            IATIN(IJ) = IATIN(IJ) + 1
 6                         ELSE
 6                            IDABN(IJ) = IDABN(IJ) + 1
 6                         END IF
 5                      END IF
 4                   ELSE
 4          IF ( PATMOD)
 4        1    WRITE (6,998) IJ,BR,KP,MSEC,SMPWRI,SMPWRS,SEN,DFPWRI
 4     998   FORMAT(' FMT 998 ',I3,2X,F10.3,5X,2(I5,5X),4(F10.3,5X))
 4                      IF (SMPWRS.GE.SEN) THEN     @ COUNT SUM SUPPRESSIONS
 5                         IF (KTYP.EQ.0) THEN
 6                            IATSU(IJ) = IATSU(IJ) + 1
 6                         ELSE
 6                            IDABS(IJ) = IDABS(IJ) + 1
 6                         END IF
 5                      ELSE IF ((SMPWRI.GT.DFPWRI).AND.(SMPWRI.GE.SEN)) THEN
 5   C      C' INT SUM INTERROGATIONS
 5                         IF (KTYP.NE.0) THEN
 6                            IDABN(IJ) = IDABN(IJ) + 1
 6                         ELSE
 6                            IATIN(IJ) = IATIN(IJ) + 1
 6                         END IF
 5                      END IF
 4                   END IF
 3     111         CONTINUE
 2    1007      CONTINUE
 2   *
 1          ITOT = IATSU(IJ) + IDABS(IJ) + IDABN(IJ) + IATIN(IJ)
 1   C      IF( ITOT .GT. 0)WRITE(6,16)II,IJ,IATSU(IJ),IDABS(IJ),IDABN(IJ)
 1   C    2    ,IATIN(IJ)
 1   16     FORMAT(' ATMOD: II IJ ATSU DABS DABN ATIN ',6I5)
 1   *
 1     200 CONTINUE
 1   *
            RETURN
     *
     C      DEBUG INIT(IATSU,IDABS,IDABN,IATIN)
            END

END FTN 597 IBANK 197 DBANK 72823 COMMON

@HOG,P  ***       BEAR       ***
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```
***        BEAR        ***

@FTN,S B.BEAR,BEAR
FTN 11R1     02/27/85-16:35(19,)
      SUBROUTINE BEAR
C
C     CALCULATES HORIZONTAL DISTANCE IN NMI AND ANGLE IN RADIANS BETWEEN TCAS
C     AND VICTIM AIRCRAFT.
C
      COMMON/BBBEAR/TLAT,TLON,RLAT,RLON,DIST,BEARTX
C
C  RADIUS OF THE EARTH IN NMI:
      RADIUS = 3441.0
C
C  DIFFERENCE IN LATITUDES AND LONGITUDES OF TWO AIRCRAFT IN RADIANS:
      DLAT = TLAT - RLAT
      DLON = TLON - RLON
C
C  COSINE OF THE AVERAGE LATITUDE (SCALING FACTOR FOR LONGITUDE)
      CS = COS (0.5*(RLAT + TLAT))
C
C  SCALED DIFFERENCE IN LONGITUDES:
      DLON = DLON*CS
C
C  DISTANCE BETWEEN TWO AIRCRAFT IN NMI CALCULATED USING THE PYTHAGOREAN
C  THEOREM:
      DIST = RADIUS * SQRT(DLAT*DLAT + DLON*DLON)
C
C  CHECK DIFFERENCE IN LONGITUDES TO PREVENT DIVISION BY ZERO IN THE
C  BEARING CALCULATION:
      IF ( ABS(DLON*RADIUS) .LT. 0.001) DLON = 0.001/RADIUS
C
C  CALCULATE THE ANGLE BETWEEN THE TWO AIRCRAFT:
      BEARTX = ATAN (-DLAT/DLON)
C
C  ADJUST THE AXIS:
      BEARTX = -BEARTX + 1.5707964
C
C  MAKE SURE THAT THE ANGLE IS GIVEN AS A POSITIVE VALUE:
      IF (DLON.LE.0.0) BEARTX = BEARTX + 3.1415927
C
      RETURN
      END

END FTN 83 IBANK 35 DBANK 6 COMMON
```

```
***       CIRCAS       ***

@FTN,S A.CIRCAS,A.CIRCAS
FTN 11R11R1A 05/30/85-13:14(17,)
      C
      C      THIS MODULE IS THE DRIVER FOR THE TCAS SIGNAL ENVIRONMENT MODEL.  IT
      C      SPECIFICALLY ACCESSES SUBROUTINES THAT:
      C                                     1. LOAD AIRCRAFT FILES
      C                                     2. SET TRANSPONDER CHARACTERISTICS
      C                                     3. SCHEDULE TCAS II M EMISSIONS
      C                                     4. COMPUTE TCAS EFFECTS
      C
      C
             INCLUDE RESTART,LIST
      *
             PARAMETER (NUAIR = 743)
      C
      C      THE LOGICAL VARIABLE PRINT, WHEN FALSE, WILL SUPPRESS ALL WRITE
      C      STATEMENTS IN THE MODEL.
      C
             LOGICAL PDISMD,PINTLI,PTCSMT,PATMOD,PDISIN,PFILES,PFRUIT,PSTATS
             COMMON /PRTBL/ PDISMD,PINTLI,PTCSMT,PATMOD,PDISIN,PFILES,PFRUIT,
            2  PSTATS
      *
             DIMENSION TJFILE(NUAIR,8), IJFILE(NUAIR,8), ICASFI(83,NUAIR,1)
             COMMON /TCDATA/ I111(83), DENS(83),
            ?   IATIN(NUAIR), IATSU(NUAIR), IDABN(NUAIR), IDABS(NUAIR)
             EQUIVALENCE (TJFILE,IJFILE)
             COMMON /CAS/ ICASFI, TJFILE, NAC, II, PRINT
             INCLUDE BBBEAR,LIST
               COMMON /BBBEAR/ TLAT, TLON, RLAT, RLON, DIST, BEARTX
             INCLUDE DPLYMT,LIST
               COMMON /DPLYMT/ IATCR, IDAB, ITCA, RATIO
             INCLUDE TCAA,LIST
               COMMON /TCAA/ NUMTCA
             INCLUDE TEMP,LIST
               COMMON /TEMP/ ITIME
             LOGICAL T1
      C
      C      LOADS FILES, SETS INITIAL CONDITIONS, COMPUTES NEAR TIME-INDEPEKDENT
      C      TCAS I EFFECTS
      C
      *         READ IN PRINT OPTIONS FROM 1ST LINE OF FILE 7.
      *
             READ(7,15)ISIMT,RATIO,T1,PDISMD,PINTLI,PTCSMT,PATMOD,PDISIN,
            2  PFILES, PFRUIT
             WRITE(6,25) T1,PDISMD,PINTLI,PTCSMT,PATMOD,PDISIN,PFILES,PFRUIT
      15     FORMAT(I3,1X,F5.0,1X,8(L1,1X) )
      25     FORMAT('  OPTIONS:',8(1X,L1,1X),/)
      *
             WRITE(6,*)'  THE TOTAL SIMUATION TIME =',ISIMT,'  RATIO=',RATIO
      *
             CALL INIT                  @ INITIALIZE ALL COMMON VARIABLES
             CALL ASPINT                @ INITIALIZE ATCRBS SUM POWER ARRAY
             CALL INPUT                 @ LOAD AIRCRAFT FILE AND RATES
             CALL TRANSP                @ LOAD A/C EMMISION CHARACTERISTICS
             CALL TSTART                @ SET TCAS II M SQUITTER PHASE

             CALL LOAD                  @ LOAD TCAS TABLES
```

```
***      CIRCAS      ***

               CALL PRESET              @ APPPROXIMATE INTERFERENCE EFFECTS
               IF (T1) CALL TCAS1       @ COMPUTE TCAS I EFFECTS
          C
          C    THE FOLLOWING LOOP CALCULATES TCAS II M TIME-DEPENDENT EFFECTS
          C
               DO 1000 ITIME = 1,ISIMT   @ SIMULATION CLOCK
          C       MOVE AND RELOAD TCAS II M TABLES EVERY 40 SECONDS
1                 IF(MOD(ITIME,40).EQ.0)  CALL LOAD
1         *
1         C
1                 DO 6 II = 1, NUMTCA    @ COMPUTE TCAS II EFFECTS (II IS TCAS ID)
1         C
1         C           LOAD TOP AND BOTTOM ANTENNA COUPLINGS BETWEEN TCAS II M AND ALL
1         C           OTHER AIRCRAFT.
2                   CALL ANTGAN
2         C
2         C           COMPUTE FRUIT RATE AT TCAS II M EVERY 20 SECONDS.  FRUIT RATES ARE
2         C           USED TO DETERMINE EFFECTS ON DETECTION PERFORMANCE.
2                   IF  ( (ITIME.EQ.1) .OR. (MOD(ITIME,20) .EQ. 0) ) CALL FRUITA
2         C
2                   CALL DISMOD (LPLUS1)
2         C
2         C           COMPUTE SMOOTH VALUES OF TCAS II M INTERROGATION RATES AND
2         C           TRANSMISSION POWER LEVELS.
2                   CALL TCSMOT
2         C
2         C           COMPUTE MODE S EFFECTS
2                   IF (LPLUS1.NE.0)  CALL DISINT
2         C
2         C           COMPUTE WHISPER-SHOUT EFFECTS FROM TCAS II M TO ALL OTHER AIRCRAFT
2                   IF ((ITIME.EQ.1).OR.(MOD(ITIME,40).EQ.0)) CALL ATMOD
2         C
2         C          ADJUST TCAS II M CHARACTERISTICS TO SATISFY INTERFERENCE-LIMITING
2         C           INEQUALITIES
2                   IF (ITIME .GE. 5) CALL INTLI
2         C
2                   CALL STATS(' CIRCAS')
2         *
2           6     CONTINUE
2         *
1
1
1         C
1           1000 CONTINUE
1         C
1         C    CALL FILES               @ LOAD RATE FILES FOR ATC MODEL.
               END

END FTN 134 IBANK 105 DBANK 70774 COMMON

@HDG,P  ***      CNVRT      ***
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```
***       CNVRT       ***

@FTN,S 8.CNVRT,CNVRT
FTN 11R1     02/27/85-16:35(10,)
                 SUBROUTINE CNVRT (K)
            C
            C    THIS SUBROUTINE DETERMINES THE AIRCRAFT TYPES
            C    ' '=0
            C    'DABS'=1
            C    'TCAS'=3
            C
                 DEFINE FLD(I,J,K) = BITS(K,I+1,J)
                 IF (FLD(0,6,K).EQ.9) THEN                  @ MODE S
  1                 K=1
  1              ELSE IF ((FLD(0,6,K).EQ.25).OR.(FLD(0,6,K).EQ.7)) THEN
  1                 K=3                                      @ TCAS II M
  1              ELSE                                        @ ATCRBS
  1                 K=0
  1              END IF
                 RETURN
                 END

END FTN 44 IBANK 12 DBANK
```

```
***        DISINT        ***

@FTN,S 6.DISINT,DISINT
FTN 11R1    02/27/85-16:35(61,)
              SUBROUTINE DISINT
        C
        C     THE PURPOSE OF THIS SUBROUTINE IS TO COMPUTE MISADDRESSED RATES AND
        C        ADDRESSED RATES AT EACH AIRCRAFT.
        C
        C     ****************INPUTS / OUTPUTS  *********************************
        C
        C     COMMON BLOCKS /     VARIABLES
        C                      INPUTS  OUTPUTS      DESCRIPTIONS
        C
        C          ATE     / DRATE                  TOTAL INTERROGATIONS RECEIVED
        C                                             BY EACH TCAS II M
        C          CSA     / II                     TCAS II M IDENTITY
        C                    NAC                    NUMBER OF AIRCRAFT IN DEPLOYMENT
        C          DPLYMT / IATCR                   NUMBER OF ATCRBS AIRCRAFT
        C          ILMS    / AMSP                   ADJUSTED TCAS II M EMISSION POWER
        C          MISAD   / MIS       MIS          MISADDRESSES AT EACH AIRCRAFT
        C          ONT     / DINTRT   DINTRT        ADDRESSED RATE TO EACH AIRCRAFT
        C                    UPRATE   UPRATE        TOTAL NUMBER OF INTERROGATIONS REC'D
        C          SENS    / JSENS                  SENSITIVITY LEVELS OF ALL AIRCRAFT
        C          SETA    /          ADRESS        NUMBER OF ADDRESSES
        C          SINT    / ITOB                   INDICATES ANTENNA ON WHICH TCAS II M
        C                                             TRANSMITTED
        C                    LPLUS                  NUMBER OF TCAS II M TRANSMISSIONS
        C          TCAA    / NUMTCA                 NUMBER OF TCAS II M A/C
        C          TCDATA / I111                    TCAS II M POINTER FILE
        C          TEMP    / ITIME                  ELAPSED TIME
        C          TRAX    / JTRANS                 TRANSMISSION POWER FOR ALL AIRCRAFT
        C                    JSENS                  SENSITIVITY LEVELS FOR ALL AIRCRAFT
        C
        C
              INCLUDE RESTART,LIST
              PARAMETER (NUAIR = 328)
        C
        C     THE LOGICAL VARIABLE PRINT, WHEN FALSE, WILL SUPPRESS ALL WRITE
        C     STATEMENTS IN THE MODEL.
        C
              LOGICAL PRINT
              DIMENSION TJFILE(NUAIR,8), IJFILE(NUAIR,8), ICASFI(83,NUAIR,1)
              COMMON /TCDATA/ I111(83), DENS(83),
             ?  IATIN(NUAIR), IATSU(NUAIR), IDABN(NUAIR), IDABS(NUAIR)
              EQUIVALENCE (TJFILE,IJFILE)
              COMMON /CAS/ ICASFI, TJFILE, NAC, II, PRINT
              COMMON/ATE/DRATE(83)
              COMMON/ONT/DINTRT(NUAIR),UPRATE(NUAIR)
              COMMON/MISAD/MIS(NUAIR)
              COMMON/TEMP/ITIME
              COMMON/TCAA/NUMTCA
              COMMON/ILMS/KCARR(83),AMSP(83),IRESET(83)
              COMMON/TRAX/JTRANS(NUAIR)
              COMMON/SENS/JSENS(NUAIR)
              COMMON/SETA/ADRESS(NUAIR)
              COMMON/SINT/LPLUS,K,ITOB(100)
              COMMON/DPLYMT/IATCR,IDAB,ITCA
              INTEGER SA
              DEFINE FLD(I,J,K) = BITS(K,I+1,J)
        C
```

```
***        DISINT        ***

        C
               SA = I111(II)                           @ TCAS II M IDENTITY
               DO 7   N = 1, NAC                       @ LOOP OVER ALL AIRCRAFT
1                 IF (ICASFI(II,N,1).EQ.0) GO TO 7     @ SKIP IF OUT OF TCAS IIM RANGE
1                 IF (N.EQ.SA) GO TO 7                 @ DO NOT PICK TCAS IIM AS VICTIM
1       C
1       C      GET ANTENNA COUPLINGS BETWEEN TCAS II M AND VICTIM AIRCRAFT.
1       C      THE FACTOR OF 2**27 SHIFTS BITS UP AND THEN BACK DOWN AGAIN TO RECOVER
1       C      THE SIGN BIT.
1       C
1                 KGN1=(FLD(00,09,IJFILE(N,8))*(2**27)) @ TCAS II M TOP ANTENNA GAIN
1                 KGN1=KGN1/(2**27)
1                 GN1=KGN1/10.+4.7-1.9
1                 KGN2=(FLD(09,09,IJFILE(N,8))*(2**27)) @ VICTIM TOP ANTENNA GAIN
1                 KGN2=KGN2/(2**27)
1                 GN2=KGN2/10.
1                 KGN3=(FLD(18,09,IJFILE(N,8))*(2**27)) @ TCAS II M BOTTOM ANTENNA GAIN
1                 KGN3=KGN3/(2**27)
1                 GN3=KGN3/10.+4.7-1.9
1                 KGN4=(FLD(27,09,IJFILE(N,8))*(2**27)) @ VICTIM BOTTOM ANTENNA GAIN
1                 KGN4=KGN4/(2**27)
1                 GN4=KGN4/10.
1                 IQ=FLD(34,2,ICASFI(II,N,1))           @ VICTIM AIRCRAFT TYPE
1                 DO 6 M=1,LPLUS                        @ LOOP OVER ALL TCAS IIM
1       C                                                 INTERROGATIONS.
2                    IF (ITOB(M).EQ.1) GS = GN1         @ TRANSMIT TOP.
2                    IF (ITOB(M).EQ.3) GS = GN3         @ TRANSMIT BOTTOM.
2                    GV = GN2
2                    IF ((GN4.GT.GN2).AND.(IQ.NE.0)) GV = GN4
2                    GNTOT = GS + GV                    @ TOTAL ANTENNA COUPLING.
2                    IPRW = FLD(17,10,ICASFI(II,N,1))   @ POWER LOSS (FREE SPACE).
2                    PRW = IPRW
2                    ATRANS = JTRANS(SA)/1 000 000.     @ TRANSMISSION POWER (KWATTS)
2                    CTRANS = ATRANS*1000.              @                    (WATTS)
2                    RVPR3 = -(PRW/10.) + 10.*ALOG10(ATRANS) - 3.0
2             ?      - 10.*ALOG10(CTRANS/AMSP(II))
2                    POWY = RVPR3 + GNTOT               @ TOTAL POWER AT VICTIM
2       C
2       C         IF TOTAL POWER VICTIM RECEIVED IS GREATER THAN VICTIM SENSITIVITY,
2       C         COUNT A MISADDRESS AT VICTIM:
2                    IF (POWY.GE.JSENS(N)) MIS(N) = MIS(N) + 1
2            6    CONTINUE
1            7 CONTINUE
1       C
1       C      CHECK ARRAYS FOR PROPER SQUITTER COUNTING AND MISADDRESSED RATE.
1       C
               IF (II.EQ.NUMTCA) THEN                  @ COMPUTE AVERAGES AFTER ALL
1                 DO 4000  NB = 1, NAC                 @ PICK A VICTIM AIRCRAFT.
1       C
1       C         DINTRT IS THE ARRAY FOR EACH MODE S TRANSPONDER THAT RECEIVES
1       C         TCAS II M INTERROGATIONS
1       C
2                    IF (IJFILE(NB,4).NE.0) DINTRT(NB) = DINTRT(NB) + 1
2                    UPRATE(NB) = UPRATE(NB)+DINTRT(NB) @ TOTAL NUMBER OF INTERROGATIONS
2                    ADRESS(NB) = DINTRT(NB)            @ # OF ADDRESSES RCVD THIS TIME
2                    DINTRT(NB) = 0.                    @ RESET COUNTER
2        4000     CONTINUE
1              END IF
               RETURN
```

```
***        DISINT        ***
      106.          END
END FTN 334 IBANK 92 DBANK 33736 COMMON
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```
***     DISMOD      ***

@FTN,S B.DISMOD,DISMOD.
FTN 11R1      02/27/85-16:35(25,)
          SUBROUTINE DISMOD(LPLUS1)
    C
    C
    C     THE PURPOSE OF THIS SUBROUTINE IS TO SCHEDULE MODE S DISCRETE
    C        INTERROGATIONS.
    C
    C     ********************    INPUTS / OUTPUTS     ***********************
    C
    C     COMMON BLOCKS /    VARIABLES
    C                        INPUTS   OUTPUTS        DESCRIPTION
    C
    C          ADJSEN    / SESIT                     ADJUSTED TCAS II M SENSITIVITIES
    C          ATE       /            DRATE          INTERROGATION RATE AT EACH TCASIIM
    C          CAS       / ICASFI                    TCAS II M ENVIRONMENTAL FILE
    C                      II                        TCAS II M IDENTIFIER
    C                      IJFILE                    TYPE OF EACH AIRCRAFT
    C                      TJFILE                    AIRCRAFT CHARACTERISTICS FILE
    C          FRUT      / FRUIT                     FRUIT LEVEL SEEN BY EACH TCAS IIM
    C          ILMS      / AMSP                      ADJUSTED TCAS II M POWER LEVELS
    C          MISAD     / MIS                       MISADDRESSES
    C          ONT       /            DINTRT         ADDRESSED RATE TO EACH AIRCRAFT
    C                      UPRATE                    TOTAL NUMBER OF INTERROGATIONS RCD
    C          RCACQ     / IROL                      MAXIMUM INTERROGATION RATE IN ROLL
    C                      ITRIL1,2,3,4              MAXIMUM FAILED INTERROGATIONS/SCAN
    C          ROLACQ    /            ACQSUM         MODE S INTERROGATION RATE COUNT
    C                                 DORSUM         # TCAS II M IN DORMANCY STATE
    C                                 MAQ            ACQUISTION COUNTER
    C                                 MDOR           DORMANCY COUNTER
    C                                 MROL           ROLL CALL COUNTER
    C                                 MSQ            SQUITTER STATE COUNTER
    C                                 NULL           NULL STATE COUNTER
    C                                 ROLSUM         NUMBER OF AIRCRAFT IN ROLL CALL
    C          SENS      / JSENS                     AIRCRAFT SENSITIVITIES
    C          SINT      /            ITOB           INDICATES WHERE TCAS IIM XMITTED
    C                                 K              VICTIM AIRCRAFT
    C                                 LPLUS          TCAS II M TRANSMISSIONS
    C          SURV      / ITRACK     ITRACK         MODE S TRACK FILE
    C          TCDATA    / I111                      TCAS II M POINTER FILE
    C          TEMP      / ITIME                     ELAPSED TIME IN SIMULATION
    C          TRAX      / JTRANS                    AIRCRAFT TRANSMISSION POWERS
    C
    C
          INCLUDE RESTART,LIST
          PARAMETER (NUAIR = 328)
    C
    C     THE LOGICAL VARIABLE PRINT, WHEN FALSE, WILL SUPPRESS ALL WRITE
    C     STATEMENTS IN THE MODEL.
    C
          LOGICAL PRINT
          DIMENSION TJFILE(NUAIR,8), IJFILE(NUAIR,8), ICASFI(83,NUAIR,1)
          COMMON /TCDATA/ I111(83), DENS(83),
         ?   IATIN(NUAIR), IATSU(NUAIR), IDABN(NUAIR), IDABS(NUAIR)
          EQUIVALENCE (TJFILE,IJFILE)
          COMMON /CAS/ ICASFI, TJFILE, NAC, II, PRINT
          COMMON/ADJSEN/SESIT(83)
          COMMON/ATE/DRATE(83)
          COMMON/ONT/DINTRT(NUAIR),UPRATE(NUAIR)
```

```
***        DISMOD        ***

          COMMON/FRUT/FRUIT(83)
          COMMON/TEMP/ITIME
          COMMON/RCACQ/ITRIL1(6),ITRIL2(6),ITRIL3(6),ITRIL4(6),IROL(10)
          COMMON/SURV/ITRACK(83,500)
          COMMON/ROLACQ/ROLSUM,ACQSUM,DORSUM,MROL,MAQ,MDOR,MSQ,NULL
          COMMON/TCAA/NUMTCA
          COMMON/ILMS/KCARR(83),AMSP(83),IRESET(83)
          COMMON/SMOOTH/NOW(83),TIS(83),TPS(83)
          COMMON/TRAX/JTRANS(NUAIR)
          COMMON/SENS/JSENS(NUAIR)
          COMMON/SINT/LPLUS,K,ITOB(100)
          COMMON/MISAD/MIS(NUAIR)
          DEFINE FLD (I,J,K) = BITS (K, I+1, J)
      C
          IF (II.EQ.1) THEN
 1           CSUM = 0.
 1           ROLSUM = 0.
 1           ACQSUM = 0.                        @ CLEAR OUT COUNTERS
 1           DORSUM = 0.                        @ AS EACH NEW
 1           MROL = 0                           @ SEARCH CYCLE BEGINS.
 1           MAQ = 0
 1           MDOR = 0
 1           MSQ = 0
 1           NULL = 0
 1           SSUM = 0.
 1           CALL MOVEKA (NUAIR,0,IATIN)
 1           CALL MOVEKA (NUAIR,0,IATSU)
 1           CALL MOVEKA (NUAIR,0,IDABN)
 1           CALL MOVEKA (NUAIR,0,IDABS)
 1           CALL MOVEKA (NUAIR,0,MIS)
 1        END IF
 1    C
 1    C
          NTRK = 500
          DRATE(II) = 0.
      C
      C      GET TCAS ALTITUDE, ZERO OUT COUNTERS.
      C
          IH = I111(II)                         @ TCAS POINTER
          AL2 = TJFILE(IH,3)/5280.              @ TCAS ALTITUDE IN MILES
          LPLUS = 0
          LPLUS1 = LPLUS
          NOW(II) = 0
      C
      C
          DO 20 IF=1,NTRK                       @ LOOP AROUND ALL A/C
      C                                           IN TRACK FILE
 1           IPLUS = 0
 1           ITRY = 0
 1           IF (ITRACK(II,IF).EQ.0) GO TO 20
 1           K = FLD(0,10,ITRACK(II,IF))
 1           MTIME = ITIME - 1
 1           IF (MTIME.LT.1) MTIME=1            @ TO KEEP FROM DIV. BY ZERO
 1           A = UPRATE(K)/MTIME
 1           N = UPRATE(K)/MTIME
 1           FR = A - N
 1           CALL RANN(RAN)
 1           IF (RAN.LE.FR) N = N + 1
 1           IF (N.LT.1) N = 1
```

```
***        DISMOD        ***

      AL1 = TJFILE(K,3)/5280.                     @ ALTITUDE OF VICTIM A/C
      ADAL = ABS(AL2-AL1)
      SR = FLD(0,9,ICASFI(II,K,1))/10.            @ SLANT RANGE BETWEEN TWO A/C
      ITEMP = FLD(34,2,ICASFI(II,K,1))            @ A/C TYPE
      IF (ITEMP.EQ.0) GO TO 20                    @ ELIMINATE ATCRBS A/C
      RVPR = FLD(17,10,ICASFI(II,K,1))
      ATRANS = JTRANS(IH)/1 000 000.
      CTRANS = 1000.*ATRANS
      RVPR1 = -(RVPR/10.) + 10.*ALOG10(ATRANS) - 3.0
     1  - 10.*ALOG10(CTRANS/AMSP(II))
      BTRANS = JTRANS(K)/1 000 000.
      RVPR2 = -(RVPR/10.) + 10.*ALOG10(BTRANS) - 0.7 - 0.3 - 3.0
C
C  REPLY POWER OF MODE S AND TCAS II M TRANSPONDERS DIFFERS BY 2.2 DB.
C
      IF (IJFILE(K,4).EQ.3) RVPR2 = RVPR2 - 2.2
      IGN1 = (FLD(00,09,IJFILE(K,8))*(2**27))
      IGN2 = (FLD(09,09,IJFILE(K,8))*(2**27))
      IGN3 = (FLD(18,09,IJFILE(K,8))*(2**27))
      IGN4 = (FLD(27,09,IJFILE(K,8))*(2**27))
      GN1 = FLOAT(IGN1/(2**27))/10. + 4.7 - 1.9
      GN2 = FLOAT(IGN2/(2**27))/10.
      GN3 = FLOAT(IGN3/(2**27))/10. + 4.7 - 1.9
      GN4 = FLOAT(IGN4/(2**27))/10.
      GS = GN1
      IF (GN3.GT.GN1) GS = GN3
      GV = GN2
      IF (GN4.GT.GN2) GV = GN4
      GNGDUP = GS + GV
      PWI = RVPR1 + GNGDUP                        @ INTERROGATION POWER
      PWR = RVPR2 + GNGDUP                        @ REPLY POWER
C
C    IF VICTIM A/C IS TCAS II M-EQUIPPED AND ITS REPLY POWER IS ABOVE THE
C    SENSITIVITY OF THE TCAS INTERROGATOR OF INTEREST, RUN SUBR. TSQUIT.
C
      IF ((ITEMP.EQ.3).AND.(PWR.GE.JSENS(IH))) CALL TSQUIT
C
C    THE NEXT SEGMENT OF CODE FINDS THE PROBABILITY OF CLEAR RECEPTION OF
C    THE VICTIM'S REPLY SIGNAL BY THE TCAS II M AIRCRAFT USING A CURVE-FITTING
C    TECHNIQUE.  THE CURVES WERE SUPPLIED BY LINCOLN LABVORATORY AND MAY BE
C    CONSIDERED SINUSOIDAL IN NATURE FOR THE INTERVAL UNDER CONSIDERATION.
C
      IF (FRUIT(II).LE.0) FRUIT(II) = 100.
      SHIFT = 3. + 10.*ALOG10(FRUIT(II)/11 800)
      OSIXX = -69.
      ORHO = OSIXX + SHIFT
      POW = PWR + 3.0
      T = 28.
      IF (POW.GT.ORHO) T = 32.
      PW = (-ORHO + POW)*2*3.14159 / T
      PDC = 0.5 + 0.5*SIN(PW)
      IF (POW.LT.(ORHO - 7.)) PDC = 0.0
      IF (POW.GT.(ORHO + 8.)) PDC = 1.0
      PDC = 0.95 * PDC
      OSIXX = -72
      ORHO = OSIXX + SHIFT
      POW = PWR + 3.0
      T = 28.
      IF (POW.GT.ORHO) T = 32.
```

```
***       DISMOD        ***

1              PW = (-ORMO + POW)*2*3.14159 / T
1              PDC1 = 0.5 + 0.5*SIN(PW)
1              IF (POW.LT.(ORMO - 7.)) PDC1 = 0.0
1              IF (POW.GT.(ORMO + 8.)) PDC1 = 1.0
1              PDC1 = 0.95*PDC1
1      C
1      C
1      C            UPDATE MODE S  TARGET  STATUS AND  SCHEDULE
1      C                           INTERROGATIONS
1      C
1      C
1              V = 600.
1              IF (TJFILE(K,3).GT.10 000) V = V + 300
1              IF (TJFILE(IH,3).GT.10 000) V = V + 300
1              TE = INT((SR*3600.)/V)
1              IALTY = 0
1              KTRIAL = FLD(22,3,ITRACK(II,IF))
1              KSCAN = FLD(25,4,ITRACK(II,IF))
1              ICLOCK = FLD(10,8,ITRACK(II,IF))*(2**28)
1              ICLOCK = ICLOCK/(2**28)
1              ISQIT = FLD(29,1,ITRACK(II,IF))
1              ISTATE = FLD(18,4,ITRACK(II,IF))
1              IF (POW.LE.(SESIT(II) + 3.)) PDC = 0.0
1              IF ((POW .LE. (SESIT(II) + 3.))  .OR.
1           1     (ISTATE .EQ. 0))    THEN                  @ NULL STATE
2                 ICONT = 0
2      C
2                 NULL = NULL + 1                           @ NULL STATE COUNTER
2                 CALL RANN (RAN)
2                 IF ((RAN.LT.PDC1).AND.(ISTATE.EQ.0)) ICONT = ICONT + 1
2                 IF (ICONT .EQ. 1) THEN
3                    ISTATE = 1                             @ 1 REPLY, GO TO SQUITTER
3                    ICLOCK = 16                            @ STATE AND SET CLOCK TO
3      C                                                      16 SINCE ENTERING FROM
3      C                                                      NULL STATE
3                 ELSE
3                    ISTATE = 0
3                    ICLOCK = 0
3                    KSCAN = 0
3                    KTRIAL = 0
3                    ISQIT = 0
3                 END IF
2              ELSE IF (ISTATE .EQ. 1) THEN                 @ SQUITTER STATE
2                 ICLOCK = ICLOCK - 1                       @ DECREMENT PURGE CLOCK;
2      C                                                      INITIALIZE AT 16 WHEN
2      C                                                      ENTERED FROM NULL STATE,
2      C                                                      0 WHEN FROM ACQ. STATE
2                 MSQ = MSQ + 1                             @ SQUITTER STATE COUNTER
2                 IF (KTRIAL .GE. 1)  THEN
3                    IF (KTRIAL .EQ. 1) THEN                @ UP COUNT INCREMENTS
4                       KSTEP = 20
4                    ELSE IF (KTRIAL .EQ. 2) THEN
4                       KSTEP = 16
4                    ELSE IF (KTRIAL .EQ. 3) THEN
4                       KSTEP = 8
4                    ELSE IF (KTRIAL .EQ. 4) THEN
4                       KSTEP = 4
4                    ELSE
4                       KSTEP = 2
```

```
***        DISMOD        ***
 4                        END IF
 3                        DO 9101  L = 1, N
 4                           CALL RANN (RAN)
 4                           IF (RAN .LT. PDC) THEN
 5                              ICLOCK = ICLOCK + KSTEP
 5                              IALTY = 1
 5                           END IF
 4                           IF (ICLOCK .GT. 0) THEN
 5                              ISTATE = 2
 5                              KSCAN = 0
 5                              KTRIAL = KTRIAL + 1
 5                              IF (KTRIAL .GT. 4) KTRIAL = 4
 5                              ICLOCK = 0
 5                              GO TO 9102
 5                           END IF
 4          9101          CONTINUE
 3                        CALL RANN (RAN)
 3                        IF (RAN .LT. PDC1) ICLOCK = ICLOCK + KSTEP
 3                        IF (ICLOCK .GE. 0) THEN
 4                           ISTATE = 2
 4                           KSCAN = 0
 4                           KTRIAL = KTRIAL + 1
 4                           IF (KTRIAL .GT. 4) KTRIAL = 4
 4                           ICLOCK = 0
 4                        ELSE IF (ICLOCK .LE. -40) THEN
 4                           ISTATE = 0
 4                           KTRIAL = 0
 4                           KSCAN = 0
 4                           ICLOCK = 0
 4                           ISQIT = 0
 4                        END IF
 3          9102          CONTINUE
 3                     ELSE IF (ICLOCK .GE. -1) THEN
 3                        ICONT = 0
 3                        DO 201  L = 1, (N-1)
 4                           CALL RANN (RAN)
 4                           IF (RAN .LT. PDC) THEN
 5                              IALTY = 1
 5                              ICONT = ICONT + 1
 5                              GO TO 210
 5                           END IF
 4           201          CONTINUE
 3                        CALL RANN (RAN)
 3                        IF (RAN .LT. PDC1)  ICONT = ICONT + 1
 3           210          CONTINUE
 3                        IF (ICONT .NE. 0) THEN
 4                           IF ((ADAL .GT. 1.700) .AND.
 4               1              (IALTY .EQ. 1)) THEN
 5                              ICLOCK = 16
 5                           ELSE
 5                              ISTATE = 2
 5                              KTRIAL = KTRIAL + 1
 5                              IF (KTRIAL .GT. 4) KTRIAL = 4
 5                              ICLOCK = 0
 5                           END IF
 4                        END IF
 3                     ELSE
 3                        ICLOCK = 0
 3                        ISTATE = 0
```

```
***       DISMOD       ***

3                    KTRIAL = 0
3                    ISQIT = 0
3                    KSCAN = 0
3                 END IF
2              ELSE IF (ISTATE .EQ. 2)  THEN           @ ACQUISITION STATE
2                 KSCAN = KSCAN + 1                    @ SCAN INCREMENT
2                 MAQ = MAQ +1                         @ ACQUISITION COUNTER
2                 IF (KSCAN  .GT. 6) THEN
3                    ISTATE = 1
3                    KSCAN = 0
3                    ICLOCK = 0
3                    ISQIT = 0
3                 ELSE
3         C  ITRIL-SUB GIVES MAX PERMISSIBLE MISSES--A FUNCTION OF TRIAL & SCAN
3                    IF (KTRIAL .EQ. 1)  ITRY = ITRIL1(KSCAN)
3                    IF (KTRIAL .EQ. 2)  ITRY = ITRIL2(KSCAN)
3                    IF (KTRIAL .EQ. 3)  ITRY = ITRIL3(KSCAN)
3                    IF (KTRIAL .GE. 4)  ITRY = ITRIL4(KSCAN)
3                    IF (ITRY .NE. 0) THEN
4                       LCOUNT = 0
4                       DO 1101 L = 1, ITRY + 1
5                          IF ((LCOUNT.LT.2).AND.((L-LCOUNT).LE.ITRY)) THEN
6                             CALL RANN(RAN)
6                             IPLUS = IPLUS + 1
6                             ITOB(LPLUS + 1) = 3
6                             IF (INT(GS).EQ.INT(GN1)) ITOB(LPLUS+1) = 1
6                             ACQSUM = ACQSUM +1         @ MODE S INTERROGATION
6         C                                                RATE COUNTER
6                             DRATE(II) = DRATE(II) + 1
6                             IF (PHI .GE. JSENS(K)) THEN
6         C                      ADDRESSED RATE TO AIRCRAFT K:
7                                DINTRT(K) = DINTRT(K) + 1
7                                IF (RAN .LT. PDC1) LCOUNT = LCOUNT + 1
7                                IF (LCOUNT .GE. 2) THEN
8                                   KSCAN = 0
8                                   KTRIAL = 0
8                                   ISQIT = 0
8                                   IF (TE .GT. 43) THEN
9                                      ISTATE = 4       @ GO TO DORMANCY STATE
9                                      ICLOCK = TE - 43
9                                      DORSUM = DORSUM + 1
9                                   ELSE
9                                      ISTATE = 3       @ GO TO ROLL CALL STATE
9                                      ICLOCK = 0
9                                   END IF
8                                END IF
7                             END IF
6                          END IF
5          1101         CONTINUE
4                       IF (LCOUNT .EQ. 1) THEN
5                          IF ((ISQIT .EQ. 1) .OR. (KSCAN .EQ. 6)) THEN
6                             IF (TE  .GT. 43) THEN
7                                KSCAN = 0
7                                KTRIAL = 0
7                                ISQIT = 0
7                                ISTATE = 4
7                                ICLOCK = TE - 43
7                                DORSUM = DORSUM + 1
7                             ELSE IF (ISQIT .EQ.1) THEN
```

```
***       DISMOD        ***

7                            ISTATE = 3
7                            ICLOCK = 0
7                            KSCAN = 0
7                            KTRIAL = 0
7                            ISQIT  = 0
7                         END IF
6                      ELSE
6                         ISQIT = 1
6                      END IF
5                   END IF
4                END IF
3             END IF
2          ELSE IF (ISTATE.EQ.3)  THEN           @ ROLL CALL STATE
2             KSCAN = KSCAN + 1
2             MROL = MROL + 1                    @ ROLL CALL COUNTER
2             IF (KSCAN .GT. 10) THEN
3                ISTATE = 1                      @ BACK TO SQUITTER
3                ICLOCK = 16
3                KTRIAL = 0                      @ ZERO TRIAL
3                KSCAN = 0                       @ ZERO SCAN
3                ISQIT = 0
3             ELSE
3                ITRY = IROL(KSCAN)
3                DO 401 L = 1, ITRY              @ DO UNTIL A REPLY IS RECEIVED
4                   CALL RANN(RAN)
4                   IPLUS = IPLUS + 1
4                   ITOB(LPLUS + 1) = 3
4                   IF (INT(GS).EQ.INT(GN1)) ITOB(LPLUS+1) = 1
4                   ROLSUM = ROLSUM + 1          @ MODE S INTERROGATION
4     C                                            RATE COUNTER
4                   DRATE(II) = DRATE(II) + 1    @ ROLL CALL INTERROGATION
4     C                                            RATE COUNTER
4                   IF (PWI.GE.JSENS(K)) THEN
5                      DINTRT(K) = DINTRT(K) + 1
5                      IF (RAN.LE.PDC1)   THEN   @ SUCCESSFUL RECEPTION OF
6                         KSCAN = 0              @ REPLY
6                         IF (TE.GT.40) THEN
7                            ISTATE = 4
7                            DORSUM = DORSUM +1
7                            ICLOCK = TE - 40
7                         END IF
6                         GO TO 402
6                      END IF
5                    END IF
4          401   CONTINUE
3          402   CONTINUE
3             END IF
2          ELSE IF (ISTATE.EQ.4) THEN            @ DORMANCY STATE
2             ICLOCK = ICLOCK - 1
2             MDOR = MDOR + 1                    @ DORMANCY COUNTER
2             IF (ICLOCK.EQ.0) THEN
3                ISTATE = 1                      @ BACK TO SQUITTER
3                ICLOCK = 16
3                KTRIAL = 0
3                KSCAN = 0
3               ISQIT = 0
3             END IF
2          END IF
1          FLD(10,8,ITRACK(II,IF)) = ICLOCK
```

```
***        DISMOD        ***

 1                  FLD(18,4,ITRACK(II,IF)) = ISTATE
 1                  FLD(22,3,ITRACK(II,IF)) = KTRIAL
 1                  FLD(25,4,ITRACK(II,IF)) = KSCAN
 1                  FLD(29,1,ITRACK(II,IF)) = ISQIT
 1                  FLD(31,1,ITRACK(II,IF)) = 0
 1                  LPLUS = LPLUS + IPLUS
 1                  LPLUS1 = LPLUS
 1           20 CONTINUE
                RETURN
                END

END FTN 1253 IBANK 240 DBANK 75362 COMMON
```

*** FILES ***

```
aFTN,S 8.FILES,FILES
FTN 11R1     02/27/85-16:35(39,)
      SUBROUTINE FILES
C
C
C        THE FUNCTION OF THIS SUBROUTINE IS TO CREATE A FILE TO BE USED AS
C     INPUT DATA TO THE DABS/ATCRBS/AIMS PPM WHICH WILL DETERMINE THE NET
C     EFFECTS OF DEPLOYING TCAS SYSTEMS IN THE ENVIRONMENT.
C
C     ******************** INPUTS / OUTPUTS **************************************
C
C     COMMON BLOCKS /     VARIABLES
C                        INPUTS   OUTPUTS     DESCRIPTION
C
C             ATE     / DRATE                 TOTAL INTERROGATIONS REC'D BY TCAS IIM
C             CAS     / NAC                   NUMBER OF AIRCRAFT
C             ILMS    / KCARR                 NUMBER OF W-S LEVELS TCAS IIM IS USING
C             MISAD   /           MIS         MODE S MISADDRESSES
C             SETA    /           ADRESS      MODE S ADDRESSES
C             TCDATA /            IATIN       ATCRBS INTERROGATIONS DUE TO TCAS II M
C                                 IATSU       ATCRBS SUPPRESSIONS DUE TO TCAS II M
C                                 IDABN       MODE S INTERROGATIONS DUE TO TCAS II M
C                                 IDABS       MODE S SUPPRESSIONS DUE TO TCAS II M
C             TCRAT1 /            ATCRAT      TCAS I INTERROGATIONS AT EACH AIRCRAFT
C
C
      INCLUDE RESTART,LIST
      PARAMETER (NUAIR = 328)
C
C     THE LOGICAL VARIABLE PRINT, WHEN FALSE, WILL SUPPRESS ALL WRITE
C     STATEMENTS IN THE MODEL.
C
      LOGICAL PRINT
      DIMENSION TJFILE(NUAIR,8), IJFILE(NUAIR,8), ICASFI(83,NUAIR,1)
      COMMON /TCDATA/ I111(83), DENS(83),
     ?   IATIN(NUAIR), IATSU(NUAIR), IDABN(NUAIR), IDABS(NUAIR)
      EQUIVALENCE (TJFILE,IJFILE)
      COMMON /CAS/ ICASFI, TJFILE, NAC, II, PRINT
      COMMON/ILMS/KCARR(83),AMSP(83),IRESET(83)
      COMMON/ATE/DRATE(83)
      COMMON/MISAD/MIS(NUAIR)
      COMMON/SETA/ADRESS(NUAIR)
      COMMON/SENS/JSENS(NUAIR)
      COMMON/TCAA/NUMTCA
      COMMON/TEMP/ITIME
      COMMON/TCRAT1/ATCRAT(NUAIR)
      KF = 0
C
C
      DO 2023  KE = 1, NAC
         IF (IJFILE(KE,4).EQ.3) THEN
            KF = KF + 1
            AMTSUP = 60.*KCARR(KF) + 100.*DRATE(KF)
         ELSE
            AMTSUP = 0.
         END IF
         WRITE (10,2025) MIS(KE),IDABS(KE),IDABN(KE),IATIN(KE),
     ?   IATSU(KE),ADRESS(KE),AMTSUP,ATCRAT(KE)
 2025    FORMAT(10X,5I15,F10.5,2X,F10.3,2X,F10.3)
```

```
***       FILES       ***

  1      47.    2023 CONTINUE
  1      48.    C
         49.          RETURN
         50.          END

END FTN 64 IBANK 107 DBANK 32975 COMMON
```

***   FRUITA   ***

```
@FTN,S 8.FRUITA,FRUITA
FTN 11R1     02/27/85-16:35(60,)
          SUBROUTINE FRUITA
     C
     C      THE PURPOSE OF THIS SUBROUTINE IS TO COMPUTE FRUIT RECEIVED AT EACH
     C         TCAS AIRCRAFT, AND TO COMPUTE THE PROBABILITY OF REPLY
     C         FOR EACH AIRCRAFT.
     C
     C         *************           INPUTS / OUTPUTS         *****************
     C
     C      COMMON BLOCKS /       VARIABLES
     C                          INPUTS      OUTPUTS     DESCRIPTION
     C
     C         CAS          / ICASFI                   TCAS II M ENVIRONMENTAL FILE
     C                        II                       TCAS II M IDENTITY
     C                        IJFILE                   A/C CHARACTERISTICS FILE
     C                        NAC                      NUMBER OF A/C
     C         FRUT         /             FRUIT        FRUIT SEEN BY EACH TCAS II M A/C
     C         MISAD        / MIS         MIS          MISADDRESSES
     C         RATE         / IADJIN                   INTERROGATION RATE FOR EACH A/C
     C                        IADJSU                   SUPPRESSION RATE FOR EACH A/C
     C         SENS         / JSENS                    SENSITIVITY LEVEL FOR EACH A/C
     C         TCDATA       / I111                     TCAS II M POINTER
     C                        IATIN                    ATCRBS INTERROGATIONS DUE TO
     C                                                 TCAS II M A/C
     C                        IATSU                    ATCRBS SUPPRESSIONS DUE TO
     C                                                 TCAS II M A/C
     C                        IDABN                    MODE S INTERROGATIONS
     C                        IDABS                    MODE S SUPPRESSIONS
     C         TPREPL       /             PREP         PROBABILITY OF REPLY FOR EACH A/C
     C         TRAX         / JTRANS                   TRANSMISSION POWER FOR EACH A/C
     C
     C
          INCLUDE RESTART,LIST
          PARAMETER (NUAIR = 328)
     C
     C    THE LOGICAL VARIABLE PRINT, WHEN FALSE, WILL SUPPRESS ALL WRITE
     C    STATEMENTS IN THE MODEL.
     C
          LOGICAL PRINT
          DIMENSION TJFILE(NUAIR,8), IJFILE(NUAIR,8), ICASFI(83,NUAIR,1)
          COMMON /TCDATA/ I111(83), DENS(83),
         ?   IATIN(NUAIR), IATSU(NUAIR), IDABN(NUAIR), IDABS(NUAIR)
          EQUIVALENCE (TJFILE,IJFILE)
          COMMON /CAS/ ICASFI, TJFILE, NAC, II, PRINT
          INTEGER STAT(2,NUAIR),KMIS(NUAIR)
          COMMON/RATE/IADJIN(NUAIR),IADJSU(NUAIR)
          COMMON/FRUT/FRUIT(83)
          COMMON/MISAD/MIS(NUAIR)
          COMMON/TPREPL/PREP(NUAIR)
          COMMON/TRAX/JTRANS(NUAIR)
          COMMON/SENS/JSENS(NUAIR)
     C
     C DELETE THE FOLLOWING COMMON STMT AFTER TESTING
          COMMON/TEMP/ITIME
     C
     C
          DEFINE FLD(I,J,K) = BITS(K,I+1,J)
          IF (II .EQ. 1) THEN                 @ AT THE BEGINNING OF EACH NEW SEARCH
```

```
***      FRUITA      ***

1                  DO 1  I = 1, NUAIR                   @ CYCLE, SAVE MISADDRESSED,
2                     KMIS(I) = MIS(I)                  @ INTERROGATION, AND SUPPRESSION
2                     IF (IJFILE(I,4) .EQ. 0) THEN      @ RATES FROM PREVIOUS SECOND.
3                        STAT(1,I) = IATIN(I)
3                        STAT(2,I) = IATSU(I)
3                     ELSE
3                        STAT(1,I) = IDABN(I)
3                        STAT(2,I) = IDABS(I)
3                     END IF
2            1     CONTINUE
1               END IF
1        C
1        C      GET IDENTITY OF TCAS II M AIRCRAFT.
                IHOLD = I111(II)
                FRUIT(II) = 0
         C
                DO 6000 IQ = 1, NAC                     @ SELECT A VICTIM AIRCRAFT.
         C
         C         CHECK THAT VICTIM AIRCRAFT IS WITHIN RANGE:
1                  IF (ICASFI(II,IQ,1).EQ.0) GO TO 6000
1                  ITY = FLD(34,2,ICASFI(II,IQ,1))     @ FIND VICTIM AIRCRAFT TYPE
1                  PLUI = STAT(1,IQ)                   @ NUMBER OF INTERROGATIONS RECEIVED
1                  PLUS = STAT(2,IQ)                   @ NUMBER OF SUPPRESSIONS RECEIVED
1                  IF (ITY .EQ. 0) THEN                @ ATCRBS A/C
2                     DEDI = PLUI * 0.000060           @ DEAD TIME IS 60 MICROSECONDS
2                     ASUP = 0.000035                  @ SUPPRESSION TIME IS 35 MICROSECONDS
2                  ELSE
2                     DEDI = PLUI * 0.000024           @ DEAD TIME IS 24 MICROSECONDS
2                     ASUP = 0.000020                  @ SUPPRESSION TIME IS 20 MICROSECONDS
2                  END IF
2        C       TOTAL SUPPRESSION TIME DUE TO GROUND ATC (IADJSU) AND TCAS II M
2        C           EMISSIONS (ADDRESSES AND MISADDRESSES):
1                  DEADI = IADJIN(IQ)*0.000060 + DEDI
1                  DEADS = IADJSU(IQ)*0.000035 + PLUS*0.000035 + KMIS(IQ)*ASUP
1                  DEADT = DEADI + DEADS               @ TOTAL DEAD TIME
1        C                                             (INTERROGATION + SUPPRESSION)
1                  PREP(IQ)=1-DEADT                    @ PROBABILITY OF REPLY
1        C                                               (1 - TOTAL DEAD TIME)
1        C
1        C       ANTENNA COUPLINGS BETWEEN TCAS II M AND VICTIM AIRCRAFT FOLLOW.  THE
1        C       FACTOR OF 2**27 SHIFTS BITS UP AND THEN BACK DOWN AGAIN TO RECOVER THE
1        C       SIGN BIT.
1                  I1=(FLD(0,9,IJFILE(IQ,5))*2**27)   @ TOP ANTENNA GAIN
1                  I2=(FLD(9,9,IJFILE(IQ,8))*2**27)   @ BOTTOM ANTENNA GAIN
1                  I3=(FLD(18,9,IJFILE(IQ,8))*2**27)  @ TOP ANTENNA GAIN
1                  I1 = I1/2**27
1                  I2 = I2/2**27
1                  I3 = I3/2**27
1                  GS = I1/10.0 + 4.7 - 1.9            @ MODE S POWER ADJUSTMENT
1                  IF ((I3/10.0+4.7-1.9).GT.GS) GS = I3/10.0 + 4.7 - 1.9
1                  GV = I2/10.0
1                  GSUM = GS + GV                      @ ANTENNA COUPLING.
1                  IPOW = FLD(17,10,ICASFI(II,IQ,1))   @ POWER COMPUTED BETWEEN TCAS II M &
1                  PWR = IPOW                          @ VICTIM AIRCRAFT
1                  PWR = -(PWR/10.) + 10.*ALOG10(JTRANS(IQ)/1000000.)-0.7-0.5-3.0
1        C      TCAS II M REPLY POWER:
1                  IF (IJFILE(IQ,4).EQ.3) PWR = PWR - 2.2
1                  PWR = PWR + GSUM                    @ TOTAL POWER
1                  IF (PWR.GE.JSENS(IHOLD)) THEN
```

```
***        FRUITA        ***

 2                      IF (ITY .NE. 0) PLUI = 0
 2          C     COMPUTE AND STORE FRUIT RATE:
 2                      FRTRAT = PREP(IQ)*IADJIN(IQ) + PREP(IQ)*PLUI
 2                      FRUIT(II) = FRUIT(II) + FRTRAT
 2                   END IF
 1            6000 CONTINUE
                  RETURN
                  END

END FTN 351 IBANK 1073 DBANK 33381 COMMON
```

```
***        HIATPW      ***

@FTN,S A.HIATPW,A.
FTN 11R11R1A 05/30/85-13:15(6,)
               FUNCTION HIATPW(NWSL)
        *
        *        THIS FUNCTION DETERMINE THE HIGHEST ATCRBS W-S LEVEL SENT WHEN A TOTAL
        *        OF NWSL ARE TRANSMITTED.
        *
        *        FIND THE HIGHEST POWER LEVEL (IN DBM) SENT
        *
               IHIPRI = 83 - NWSL + 1              @ PRIORITY OF HIGHEST LEVEL SENT
               IF( IHIPRI .LE. 63) THEN
                  POWLEV = 49 - (IHIPRI + 2)/4     @ HIGHEST POWER SENT BY TOP FRNT ANTENN
               ELSE IF( IHIPRI .LE. 80) THEN
                  POWLEV = 36                      @ HIGHEST POWER SENT BY BOTTOM
               ELSE
                  POWLEV = 36 - 2*(IHIPRI - 80)
               END IF
        *
        *         CONVERT POWLEV TO WATTS
        *
               HIATPW = 10.**((POWLEV+6-30)/10.)   @ POWLEV (DBM) + 6 DBI - 30 DBM TO MW
        *
               RETURN
               END

END FTN 64 IBANK 21 DBANK

@HDG,P ***       FILES        ***
```

```
***      INIT      ***

@FTN,S B.INIT,INIT
FTN 11R1     02/27/85-16:35(17,)
              SUBROUTINE INIT
        C
        C          THIS SUBROUTINE SETS UP INITIAL VALUES FOR ALL THE COMMON
        C     VARIABLES TO BE USED IN THE MODEL.  DETAILED DESCRIPTIONS OF ALL
        C     THE VARIABLES ARE CONTAINED IN THE DATA DICTIONARY OF THE  TCAS
        C     SIGNAL ENVIRONMENT MODEL  BY C. GILCHRIST AND G. FATRICK.
        C
              INCLUDE RESTART, LIST
        C
              PARAMETER (NUAIR = 328)
        C
        C     THE LOGICAL VARIABLE PRINT, WHEN FALSE, WILL SUPPRESS ALL WRITE
        C     STATEMENTS IN THE MODEL.
        C
              LOGICAL PRINT
              DIMENSION TJFILE(NUAIR,8), IJFILE(NUAIR,8), ICASFI(83,NUAIR,1)
              COMMON /TCDATA/ I111(83), DENS(83),
             ?   IATIN(NUAIR), IATSU(NUAIR), IDABN(NUAIR), IDABS(NUAIR)
              EQUIVALENCE (TJFILE,IJFILE)
              COMMON /CAS/ ICASFI, TJFILE, NAC, II, PRINT
              COMMON /ADJSEN/ SESIT(83)
              COMMON /ANTENN/ AZPAT(36), DIFPAT(36)
              COMMON /ANTO/ PASTOP(19), PASBOT(19)
              COMMON /ANTT/ ANTTOP (19), ANTBOT(19)
              COMMON /ATE/ DRATE(83)
              COMMON /BBBEAR/ TLAT, TLON, RLAT, RLON, DIST, BEARTX
              COMMON /DPLYMT/ IATCR, IDAB, ITCA
              COMMON /FRUT/ FRUIT(83)
              COMMON /ILMS/ KCARR(83), ANSP(83), IRESET(83)
              COMMON /LEVEL/ ISETA, JMAX, KMAX, TPOW, PMAX
              COMMON /LEVEL2/ ICHEK
              COMMON /MISAD/ MIS(NUAIR)
              COMMON /ONT/ DINTRT(NUAIR), UPRATE(NUAIR), AMEAN(200), ASDE(200)
              COMMON /RATE/ IADJIN(NUAIR), IADJSU(NUAIR)
              COMMON /RCACQ/ ITRIL1(6), ITRIL2(6), ITRIL3(6), ITRIL4(6),
             1   IROL(10)
              COMMON /ROLACQ/ ROLSUM, ACQSUM, DORSUM, MROL, MAQ, MDOR, MSQ,
             1   NULL
              COMMON /SENS/ JSENS(NUAIR)
              COMMON /SETA/ ADRESS(NUAIR)
              COMMON /SINT/ LPLUS, K, ITOB(100)
              COMMON /SMOOTH/ NOW(83), TIS(83), TPS(83)
              COMMON /SURV/ ITRACK(83,500)
              COMMON /TCAA/ NUMTCA
              COMMON /TCRAT1/ ATCRAT(NUAIR)
              COMMON /TEMP/ ITIME
              COMMON /TPREPL/ PREP(NUAIR)
              COMMON /TRAN/ TCST(83)
              COMMON /TRAX/ JTRANS(NUAIR)
              COMMON /WSCAR/ ILWS(83)
              COMMON /WSHOUT/ IPRF(24), IPRS(40), IPRB(15), IPRBOT(4),
             1   IPOWF(24), IPOWS(41), IPOWB(15), IPOWBO(4)
        C
              DO 200  I = 1, 83
1                SESIT(I) = 0.
1                DRATE(I) = 0.
1                FRUIT(I) = 0.
```

```
***       INIT        ***

1                   KCARR(I) = 83
1                   AMSP(I) = 0.
1                   IRESET(I) = 0
1                   NOW(I) = 0
1                   TIS(I) = 0.
1                   TPS(I) = 0.
1                   I111(I) = 0
1                   TCST(I) = 0.
1                   ILWS(I) = 0
1                   DENS(I) = 0.
1                   IF (I .LT. 42)  IPOWS(I) = 0
1         C
1                   DO  300  J = 1, NUAIR
2                        ICASFI(I,J,1) = 0
2           300     CONTINUE
1                   DO  375  J = 1, 500
2                        ITRACK(I,J) = 0
2           375     CONTINUE
1           200 CONTINUE
1         C
                DO  400  I = 1, NUAIR
1                   MIS(I) = 0
1                   DINTRT(I) = 0.
1                   UPRATE(I) = 0.
1                   IADJIN(I) = 0
1                   IADJSU(I) = 0
1                   JSENS(I) = 0
1                   ADRESS(I) = 0.
1                   IATIN(I) = 0
1                   IATSU(I) = 0
1                   IDABN(I) = 0
1                   IDABS(I) = 0
1                   ATCRAT(I) = 0.
1                   PREP(I) = 0.
1                   JTRANS(I) = 0
1                   DO  500  J = 1, 8
2                        TJFILE(I,J) = 0.
2           500     CONTINUE
1           400 CONTINUE
1         C
                DO  600  I = 1, 200
1                   AMEAN(I) = 0.
1                   ASDE(I) = 0.
1                   IF (I .LE. 100) ITOB(I) = 0
1           600 CONTINUE
1         C
                DO  700  I = 1, 24
1                   IPOWF(I) = 0
1                   IF (I.LE.15) IPOWB(I) = 0
1           700 CONTINUE
1         C
                TLAT = 0.0
                TLON = 0.0
                RLAT = 0.0
                RLON = 0.0
                DIST = 0.0
                BEARTX = 0.0
                NAC = 0
                IATCR = 0
```

```
***        INIT        ***

      IDAB = 0
      ITCA = 0
      ISETA = 0
      JMAX = 0
      KMAX = 0
      TPOW = 0.0
      PMAX = 0.0
      ICHEK = 0
      ROLSUM = 0.0
      ACQSUM = 0.0
      DORSUM = 0.0
      MROL = 0
      MAQ = 0
      MDOR = 0
      MSQ = 0
      NULL = 0
      LPLUS = 0
      K = 0
      NUMTCA = 0
      ITIME = 0
C
      DATA (ANTTOP(I),I=1,19)/-31.3,-16.3,-8.5,-6.0,-4.0,-3.0,-2.0,0.0
     *,0.0,-5.0,-8.0,-12.0,-16.0,-17.0,-18.0,-21.0,-25.0,-31.0,-32.0/
      DATA (ANTBOT(I),I=1,19)/-32.0,-31.0,-25.0,-21.0,-18.0,-17.0,-16.0,
     *-12.0,-8.0,-5.0,0.0,0.0,-2.0,-3.0,-4.0,-6.0,-8.5,-16.3,-31.3/
      DATA (ITRIL1(I),I=1,6)/3,3,3,0,0,0/
      DATA (ITRIL2(I),I=1,6)/2,2,2,0,0,0/
      DATA (ITRIL3(I),I=1,6)/1,1,1,0,0,0/
      DATA (ITRIL4(I),I=1,6)/1,0,0,0,0,0/
      DATA (IROL(I),I=1,10)/5,4,3,2,2,2,2,2,2,2/
      DATA (AZPAT(I),I=1,36)/0.,0.,0.,1.,2.,4.,6.,9.,15.,27.,23.,16.,
     *13.,12.,11.,11.,11.,11.,11.,11.,10.,10.,10.,11.,12.,16.,
     *25.,22.,13.,8.,5.,3.,2.,1.,0.,0./
      DATA (DIFPAT(I),I=1,36)/12.,12.,12.,13.,13.,11.,9.,6.,4.,3.,2.,
     *2.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,1.,2.,3.,4.,6.,8.,
     *11.,13.,14.,13.,13./
      DATA (PASTOP(I),I=1,19)/-31.3,-16.3,-8.5,-2.8,-0.3,1.3,2.0,2.5,
     *2.5,1.0,-0.5,-3.0,-7.0,-11.0,-14.5,-17.0,-18.0,-31.0,-32.0/
      DATA (PASBOT(I),I=1,19)/-32.0,-31.0,-18.0,-17.0,-14.5,-11.0,-7.0
     *,-3.0,-0.5,1.0,2.5,2.5,2.0,1.3,-0.3,-2.8,-8.5,-16.3,-31.3/
      DATA (IPRF(I),I=1,24)/1,5,9,13,17,21,25,29,33,37,41,45,49,53
     *,57,61,64,67,70,73,76,77,78,79/
      DATA (IPRS(I),I=1,40)/2,3,6,7,10,11,14,15,18,19,22,23,26,27,
     *30,31,34,35,38,39,42,43,46,47,50,51,54,55,58,59,62,63,65,66,
     *68,69,71,72,74,75/
      DATA (IPRB(I),I=1,15)/4,8,12,16,20,24,28,32,36,40,44,48,52,56,60/
      DATA (IPRBOT(I),I=1,4)/80,81,82,83/
      DATA (IPOWBO(I),I=1,4)/0, 0, 0, 0/
      RETURN
      END
```

```
***        INPUT        ***

@FTN,S B.INPUT,INPUT
FTN 11R1      02/27/85-16:35(9,)
                 SUBROUTINE INPUT
           C
           C     THE FUNCTION OF THIS SUBROUTINE IS TO LOAD CHARACTERTICS FROM L. A.
           C        BASIN MODEL AND RATES GENERATED FROM DABS/ ATCRBS/ AIMS/ PPM FOR
           C        EACH TRANSPONDER.
           C
           C        **************            INPUTS / OUTPUTS            **************
           C
           C     COMMON BLOCKS /       VARIABLES
           C                        INPUTS       OUTPUTS      DESCRIPTION
           C
           C        CAS        /                 TJFILE       TYPE OF EACH AIRCRAFT
           C                                     NAC          NUMBER OF AIRCRAFT
           C                                     TJFILE       AIRCRAFT CHARACTERISTICS
           C        DPLYMT     /                 IATCR        NUMBER OF ATCRBS A/C
           C                                     IDAB         NUMBER OF MODE S A/C
           C                                     ITCA         NUMBER OF TCAS II M A/C
           C        RATE       /                 IADJIN       INTERROGATION RATES FOR EACH A/C
           C                                     IADJSU       SUPPRESSION RATES FOR EACH A/C
           C
                 INCLUDE RESTART,LIST
                 PARAMETER (NUAIR = 328)
           C
           C     THE LOGICAL VARIABLE PRINT, WHEN FALSE, WILL SUPPRESS ALL WRITE
           C     STATEMENTS IN THE MODEL.
           C
                 LOGICAL PRINT
                 DIMENSION TJFILE(NUAIR,8), IJFILE(NUAIR,8), ICASFI(83,NUAIR,1)
                 COMMON /TCDATA/ I111(83), DENS(83),
                ?   IATIN(NUAIR), IATSU(NUAIR), IDABN(NUAIR), IDABS(NUAIR)
                 EQUIVALENCE (TJFILE,IJFILE)
                 COMMON /CAS/ ICASFI, TJFILE, NAC, II, PRINT
                 DIMENSION IATINR(NUAIR),ISUPRT(NUAIR)
                 COMMON/RATE/IADJIN(NUAIR),IADJSU(NUAIR)
                 CHARACTER*4 S,E,TYPE,LATB,LONB
                 EQUIVALENCE (TYPE,ITYPE),(NAC,N)
                 COMMON/DPLYMT/IATCR,IDAB,ITCA
                 DATA S2R/4.8481368E-6/                     @ SECONDS TO RADIANS
                 DATA S,E/'S','E'/
                 NAC=0                                      @ AIRCRAFT COUNTER.
                 RATIO=.420                                 @ THIS NUMBER IS (ROUGHLY) THE
           C                                                  PERCENT OF THE TOTAL DEPLOY-
           C                                                  MENT DESIRED.  CHANGE THIS
           C                                                  NUMBER TO CHANGE THE SIZE OF
           C                                                  THE DEPLOYMENT.
                 DO 100 L=1,NUAIR                           @ READ IN ATC RATES FROM
           C                                                  DABS/ATCRBS/AIMS PPM
1                  READ(8,1)IATINR(L),ISUPRT(L),DALAT,DALON @ INTERROGATION, SUPPRESSION,
1          C                                                  LATITUDE, LONGITUDE
1              1   FORMAT(10X,2I10,2F10.4)
1          C
1          C       READ THE TRANSPONDER CHARACTERISTICS FROM THE L. A. BASIN MODEL
1              2   READ(5,20,END=140)LAB,LAM,LAS,LATB,LOD,LOM,LOS,LONB,ALT,TYPE,
1             *    DX,DY,DZ
1             20   FORMAT(3I2,A1,I3,2I2,A1,3X,F8.0,9X,A4,1X,F6.4,1X,F6.4,1X,F8.4)
1                  CALL RANN(RAN)                           @ RANDOMLY ELIMINATE AIRCRAFT
1                  IF(RAN.GE.RATIO) GO TO 2                 @ FROM DEPLOYMENT TO PRODUCE
```

```
***        INPUT        ***

1      C                                             LOWER DENSITY DEPLOYMENTS.
1               IONE=1
1               CALL FASCFD(IONE,TYPE,TYPE)           @ CONVERTS TYPE FROM ASCII TO
1      C                                               FIELDATA.
1               CALL CNVRT(ITYPE)                     @ CONVERTS TYPE FROM FIELDATA
1      C                                               TO INTEGER.
1               RLAT=((LAD*3600)+(LAM*60)+LAS)*S2R    @ LATITUDE IN RADIANS.
1               RLON=((LOD*3600)+(LOM*60)+LOS)*S2R    @ LONGITUDE IN RADIANS.
1               IF(LAT8(1:1).EQ.S(1:1))RLAT=-RLAT     @ DETERMINE LOCATION
1      C                                               (N/S AND E/W).
1               IF(LON8(1:1).EQ.E(1:1))RLON=-RLON
1               N=NAC+1                               @ COUNT A/C
1      C
1      C     LOAD POSITION, VELOCITY, AND TYPE OF EACH TRANSPONDER.
1      C
1               TJFILE(N,1)=RLAT                      @ LATITUDE
1               TJFILE(N,2)=RLON                      @ LONGITUDE
1               TJFILE(N,3)=ALT                       @ ALTITUDE
1               IJFILE(N,4)=ITYPE                     @ TYPE OF TRANSPONDER
1               TJFILE(N,5)=DX                        @ DX (WESTWARD VELOCITY)
1               TJFILE(N,6)=DY                        @ DY (NORTHWARD VELOCITY)
1               TJFILE(N,7)=DZ                        @ DZ (UPWARD VELOCITY)
1               IF(IJFILE(N,4).EQ.0) IATCR=IATCR+1    @ COUNT ATCRBS TRANSPONDERS.
1               IF(IJFILE(N,4).EQ.1) IDAB=IDAB+1      @ COUNT MODE S TRANSPONDERS.
1               IF(IJFILE(N,4).EQ.3) ITCA=ITCA+1      @ COUNT TCAS TRANSPONDERS.
1               IADJIN(N)=IATINR(N)                   @ LOAD INTERROGATION RATES
1      C                                               FROM DABS/ATCRBS/AIMS PPM.
1               IADJSU(N)=ISUPRT(N)                   @ LOAD SUPPRESSION RATES
1      C                                               FROM DABS/ATCRBS/AIMS PPM.
1      C
1         100 CONTINUE
          140 CONTINUE
              RETURN
              END
*NON-STD USAGE 3128  *TYPE* EQUIVALENCED TO A NONCHARACTER ITEM

END FTN 1 NON-STD USAGES 183 IBANK 796 DBANK 31988 COMMON
```

```
@FTN,S A.INTLI
FTN 11R11R1A 06/03/85-15:05(37,)
      SUBROUTINE INTLI
C
C     THE PURPOSE OF THIS SUBROUTINE IS TO CHECK THE AMOUNT OF TCAS II M
C        INTERROGATIONS SENT (BOTH MODE S AND ATCRBS), AND TO DETERMINE
C        IF ANY OF THE THREE INTERFERENCE LIMITING INEQUALITIES ARE
C        VIOLATED. IF VIOLATED, POWER AND SENSITIVITY ADJUSTMENTS ARE
C        POSSIBLE ACCORDING TO INTERFERENCE LIMITING PROTOCOL. THIS
C        SUBROUTINE WAS MODELED ACCORDING TO THE MINIMUM OPERATIONAL
C        PERFORMANCE STANDARDS (MOPS).
C
C    *******************  INPUTS / OUTPUTS  ***********************************
C
C    COMMON BLOCKS /     VARIABLES
C                     INPUTS   OUTPUTS    DESCRIPTION
C
C          ADJSEN / SESIT    SESIT      ADJUSTED SENSITIVITY LEVELS OF TCAS II
C          CAS    / II                  TCAS II M IDENTITY
C          ILMS   / AMSP     AMSP       ADJUSTED POWER LEVELS OF TCAS II M
C                   IRESET   IRESET     16-SECOND FREEZE COUNTER
C                            NWSL       # W-S LEVELS EACH TCAS II M IS USING
C          SENS   / JSENS               SENSITIVITY LEVELS OF ALL AIRCRAFT
C          SMOOTH / NOW      NOW        NUMBER OF TCAS II M DETECTED
C                   TIS                 SMOOTHED EMISSION POWERS
C                   AVMSPW              SMOOTHED TOTAL MODE S POWER
C          TCDATA / I111                TCAS II M POINTER FILE
C          TEMP   / ITIME               ELAPSED TIME
C          TRAX   / JTRANS              TRANSMISSION POWER OF ALL AIRCRAFT
C
C
      PARAMETER ( PMATCH = 10.**( (3.0-4.7)/10.) )     @ FACTOR FOR MODE S POWER
      PARAMETER ( PMSFAC = 10.**( (-4.7)/10.) )        @ MODE S POW AT ANTENNA
      PARAMETER ( ONEDB  = 10.**(.1) )                 @ DEFINE 1 DB
*
      INCLUDE RESTART,LIST
      PARAMETER (NUAIR = 743)
C
C     THE LOGICAL VARIABLE PRINT, WHEN FALSE, WILL SUPPRESS ALL WRITE
C     STATEMENTS IN THE MODEL.
C
      LOGICAL PDISMO,PINTLI,PTCSMT,PATMOD,PDISIN,PFILES,PFRUIT,PSTATS
      COMMON /PRTOL/ PDISMO,PINTLI,PTCSMT,PATMOD,PDISIN,PFILES,PFRUIT,
     2 PSTATS
*
      DIMENSION TJFILE(NUAIR,8), IJFILE(NUAIR,8), ICASFI(83,NUAIR,1)
      COMMON /TCDATA/ I111(83), DENS(83),
     ?  IATIN(NUAIR), IATSU(NUAIR), IDABN(NUAIR), IDABS(NUAIR)
      EQUIVALENCE (TJFILE,IJFILE)
      COMMON /CAS/ ICASFI, TJFILE, NAC, II, PRINT
      INCLUDE TEMP,LIST
        COMMON /TEMP/ ITIME
      INCLUDE ILMS,LIST
        COMMON /ILMS/ NWSL(83), AMSP(83), IRESET(83), ATSUMP(0:83),
     2    IRETRN, TPOW
      INCLUDE SMOOTH,LIST
        COMMON /SMOOTH/ NOW(83), AVMSPW(83),TIS(83)
      INCLUDE ADJSEN,LIST
        COMMON /ADJSEN/ SESIT(83)
```

```
      INCLUDE ATE,LIST
        COMMON /ATE/ IRATL(33)
      INCLUDE TRAX,LIST
        COMMON /TRAX/ JTRANS(NUAIR)
      INCLUDE SENS,LIST
*
*
        COMMON /SENS/ JSENS(NUAIR)
      ID = I111(II)                      @ ID OF TCAS II M OF INTEREST
      IRESET(II)=IRESET(II)-1            @ DECREMENT FREEZE CLOCK
      RSEQ1 = 7.E+4/(1 + NOA(II) )       @ 250W * 280 A/C / (1 + NOF TCAS DET BY SQ)
      RSEQ3 = 2.E+4/(1 + NOW(II) )       @ 250W * 80 A/C / (1 +NOW)
*
* POINT 1: ELIMINATE W-S STEPS TO STASIFY EQUATION 3
*
10    IF( ATSUMP(NWSL(II) ) .GT. RSEQ3) THEN
         IF( NWSL(II) .EQ. 0) THEN    @ CHECK IF ANDY W-S STEP ARE LEFT
            IRETRN = 0
            RETURN
         END IF
         NWSL(II) = NWSL(II) - 1       @ REMOVE 1 W-S LEVEL
         GO TO 10                      @ RECHECK EQUATION 3
      END IF
*
* POINT 2: CHECK TO SEE IF 16 SEC FREEZE ON MODE S VARIATIONS IS ON
*
      IF( IRESET(II) .GT. 0 .AND. ITIME .GT. 15) THEN
         IRETRN = 1                    @ SEE FIGURE 3-3
         RETURN.
      ELSE                             @ FREEZE IS OFF
*
* POINT 3: CHECK EQUATIONS 1 AND 3
*
20       TMSPOW = AVMSPW(II)*PMSFAC   @ AVERAGE RATE * AVERAGE POWER (IN WATTS)
         TATPOW = ATSUMP( NWSL(II) )  @ TOTAL ATCRBS POWER
         TPOW = TMSPOW + TATPOW       @ TOTAL POWER RADIATED IN LAST SECOND
         LSEQ2 = 60*NWSL(II) + 100*NINT(TIS(II) ) @ # OF USEC OF SELF-SUPRESSION
*
         IF( TPOW .LT. RSEQ1 .AND. LSEQ2 .LT. 10000)THEN   @ EQUATIONS 1 AND 2
*
* POINT 4: CHECK TO SEE IF MODE S RANGE > ATCRBS RANGE.  SINCE THE RANGE IS
* DIRECTLY PROPORTIONAL TO THE TX POWER, AND THE ATCRBS SENS IS 3 DB > MODE S
* SENS, THE EQUIVALENT CHECK IS TO SEE IF MODE S POW + 3 DB > HIGHEST ATCRBS W-S
* LEVEL SENT. A FACTOR OF 4.7 DB MUST BE SUBTRACTED FROM THE MODE S POWER STORED
* IN AMSP(II) TO ACCOUNT FOR CABLE LOSSES AND ANTENNA GAIN ON THE HORIZON. THIS
* FACTOR MINUS THE 3 DB DUE TO SENSITIVITY DIFFERENCES IS THE PARAMETER PMATCH.
*
            IF( AMSP(II)*PMATCH .GT. HIATPW(NWSL(II)) ) THEN
*
* POINT 5: ADD 1 W-S LEVEL AND RECHECK EQUATION 3
*
               IF( NWSL(II) .EQ. 83)THEN          @ ALL W-S LEVELS SENT
                  IRETRN = 2                       @ SEE FIGURE 3-3
                  RETURN
               END IF
               TATPOW = ATSUMP( NWSL(II) +1)      @ ADD W-S LEVEL
               IF(TATPOW .LE. RSEQ3) THEN
*
* POINT 6: CHECK IF ADDING A W-S LEVEL VIOLATES EQUATIONS 1 OR 2
```

```
3      *
4                      TPOW = TATPOW + TMSPOW
4                      IF(TPOW .GT. RSEQ1 .OR. LSEQ2+60 .GT.10000)THEN
5                         IRETRN = 3                     @ SEE FIGURE 3-3
5                         RETURN                         @ POINT 7
5                      ELSE
5                         NWSL(II) = NWSL(II) + 1        @ POINT 8
5                         GO TO 20                       @ GO TO POINT 3
5                      END IF                            @ END FOR POINT 6
4                   END IF                               @ END FOR POINT 5
3                END IF                                  @ END FOR POINT 4
3      *
3      * POINT 9: CHECK TO SEE IF MODE S RANGE CAN BE INCREASED
3      *
2                POWMS = JTRANS(ID)/1000.                @ MAX MODE S POWER IN WATTS
2                IF( AMSP(II) .LT. POWMS)THEN            @ INST POW < MAX POW
3                   AMSP(II) = AMSP(II) * ONEDB          @ 1 DB INCREASE IN POWER
3                   SESIT(II) = SESIT(II) - 1.           @ 1 DB DECREASE IN MTL
3                   IRESET(II) = 16                      @ POINT 15 RESET FREEZE
3                   IRETRN = 4
3                   RETURN
3                ELSE
3                   IRETRN = 5
3                   RETURN                               @ POINT 11
3                END IF
3      *
2             ELSE              @ COME HERE FROM POINT 3 IF IT IS FALSE
2      *
2      * POINT 12: DOES MODE S RANGE EXCEED ATCRBS RANGE ?
2      *
2          ATPW = HIATPW(NWSL(II) )
2          AMSPW = AMSP(II) * PMATCH
2      C   WRITE(6,16)AMSP(II),AMSPW,ATPW
2      16  FORMAT(' IN INTLI LINE 125: AMSP AMSPW ATPW',3F8.1)
2      *
2                IF( AMSP(II)*PMATCH .GT. HIATPW(NWSL(II)) ) THEN
3                   AMSP(II) = AMSP(II) / ONEDB       @ 1 DB DECREASE IN POWER
3                   SESIT(II) = SESIT(II) + 1.        @ 1 DB INCREASE IN MTL
3                   IRESET(II) = 16                   @ POINT 15: FREEZE MODE S
3                   IRETRN = 6                        @ SEE FIGURE 3-3
3                   RETURN
3                ELSE
3                   NWSL(II) = NWSL(II) - 1           @ POINT 14: DELETE 1 W-S LEVEL
3                   IF( NWSL(II) .EQ. 0)THEN          @ NO W-S LEVEL LEFT TO DELETE
4                      WRITE(6,*)'IN INTLI: ALL W-S',
4           2             ' LEVELS DELETED FOR TCAS# =',II
4                      IRETRN = 7
4                      RETURN
4                   END IF
3                   GO TO 20                          @ GO TO POINT 3
3                END IF
2             END IF                                  @
1          END IF
1      *
           RETURN
           END

END FTN 323 IBANK 99 DBANK 72999 COMMON
```

```
***       LOAD       ***

@FTN,S B.LOAD,LOAD
FTN 11R1      02/27/85-16:35(15,)
              SUBROUTINE LOAD
        C
        C     THE FUNCTIONS OF THIS SUBROUTINE ARE:
        C        1.  TO UPDATE AIRCRAFT POSITIONS
        C        2.  TO COMPUTE THE HEADING OF EACH TCAS
        C        3.  TO UPDATE MODE S TRACK ARRAY (1 TRACK)
        C        4.  TO LOAD ARRAY BETWEEN TCAS AND VICTIM AIRCRAFT (ICASFI)
        C            THAT CONTAINS POWER, RANGE, BEARING, AND TYPE
        C        5.  TO COMPUTE THE AIR TRAFFIC DENSITIES ABOUT EACH TCAS.
        C
        C     ************************ INPUTS / OUTPUTS *****************************
        C
        C     COMMON BLOCKS /     VARIABLES
        C                       INPUTS   OUTPUTS        DESCRIPTION
        C
        C          CAS     /             ICASFI         TCAS II M ENVIRONMENTAL FILE
        C                       NAC                     NUMBER OF AIRCRAFT
        C                                TJFILE         A/C CHARACTERISTICS FILE
        C          SURV    / ITRACK      ITRACK         MODE S TRACK FILE
        C          TCAA    / NUMTCA                     NUMBER OF TCAS II M AIRCRAFT
        C          TCDATA  /             DENS           A/C DENSITY ABOUT EACH TCAS II M
        C                       I111                    TCAS II M POINTER FILE
        C          TEMP    / ITIME                      ELAPSED TIME IN SIMULATION
        C
        C
              LOGICAL ZERO
              COMMON/BBBEAR/TLAT,TLON,RLAT,RLON,DIST,BEARTX
              INCLUDE RESTART,LIST
              PARAMETER (NUAIR = 328)
        C
        C     THE LOGICAL VARIABLE PRINT, WHEN FALSE, WILL SUPPRESS ALL WRITE
        C     STATEMENTS IN THE MODEL.
        C
              LOGICAL PRINT
              DIMENSION TJFILE(NUAIR,8), IJFILE(NUAIR,8), ICASFI(83,NUAIR,1)
              COMMON /TCDATA/ I111(83), DENS(83),
             ?   IATIN(NUAIR), IATSU(NUAIR), IDABN(NUAIR), IDABS(NUAIR)
              EQUIVALENCE (TJFILE,IJFILE)
              COMMON /CAS/ ICASFI, TJFILE, NAC, II, PRINT
              COMMON/SURV/ITRACK(83,500)
              COMMON/TEMP/ITIME
              COMMON/TCAA/NUMTCA
              DIMENSION THETA(83)
              DEFINE FLD(I,J,K)= BITS(K,I+1,J)
              CF = 0.0002909                          @ CONVERTS NAUTICAL MILES TO
        C                                               RADIANS.
            1 IF(ITIME.NE.0) THEN
        C
        C        UPDATE A/C POSITIONS EVERY FORTY SECONDS.
        C
                 DO 310 KR = 1, NAC
                    QLAT = TJFILE(KR,1)
                    TJFILE(KR,1) = TJFILE(KR,1) + (TJFILE(KR,6)*CF)*40.
                    TJFILE(KR,2) = TJFILE(KR,2)+(TJFILE(KR,5)*CF/COS(QLAT))*40.
                    TJFILE(KR,3) = TJFILE(KR,3) + TJFILE(KR,7)*40.
          310    CONTINUE
              END IF
```

```
***        LOAD       ***

1          C
1          C       LOAD/UPDATE ARRAYS.
1          C
              DENSU = 0.                                 @ ZERO OUT DENSITY COUNTERS
              DENSU1 = 0.
              DENSU5 = 0.
              DENSU3 = 0.
              DENS5 = 0.
              DENS30 = 0.
              DO 300 I = 1, NUMTCA                       @ LOOP OVER ALL TCAS II M A/C
           C
           C        COMPUTE HEADING OF TCAS II M
           C
1                IH = I111(I)
1                THETA(I) = ASIN(TJFILE(IH,6)/((TJFILE(IH,5)**2 +
1            1         TJFILE(IH,6)**2.)**0.5))*57.2957
1          C
1          C  THE FACTOR OF 57.2957 IN THE ABOVE EQUATION CONVERTS THE ANGLE FROM
1          C      RADIANS TO DEGREES.
1          C
1          C  THE ANGLE THETA ABOVE WAS COMPUTED IN THE FOLLOWING COORIDINATE SYSTEM:
1          C      DUE WEST IS 0 DEGREES, DUE NORTH IS 90 DEGREES, EAST IS 180 DEGREES,
1          C      AND SOUTH IS 270 DEGREES. HOWEVER THE COORIDINATE SYSTEM WE WISH TO
1          C      WORK IN IS AS FOLLOWS: NORTH AT 0 DEGREES, WEST AT 90, SOUTH AT 180,
1          C      AND EAST AT 270. THE CALCULATION ABOVE ALSO ASSUMES THAT THE PLANE
1          C      IS HEADING WEST, SO TO CORRECT THESE PROBLEMS, WE MUST SUBTRACT THE
1          C      ABOVE ANGLE FROM 90 DEGREES, AND IF IT IS HEADING EAST SUBTRACT THAT
1          C      ANGLE FROM 360 DEGREES, WHICH RESULTS IN ADDING 270 TO IT.  (NEW
1          C      THETA = 90 - THETA, AND EAST -THETA = 360 - NEW THETA = 360 - (90-
1          C      THETA) = 270 + THETA.)
1          C
1                YAW = 90. - THETA(I)
1                IF (TJFILE(IH,5).LT.0.) YAW = 270. + THETA(I)
1                THETA(I) = YAW*3.14159/180.             @ 3.14159/180 CONVERTS THE
1          C                                               ANGLE BACK INTO RADIANS
1                MAXNAC = 0
1                TLAT = TJFILE(IH,1)                     @ TCAS IIM LATITUDE IN RADIANS
1                TLON = TJFILE(IH,2)                     @ TCAS IIM LONGITUDE IN RADIANS
1                ALT1 = TJFILE(IH,3)/6076.0              @ TCAS IIM ALT IN NMI
1          C
1          C   LOOP OVER ALL AIRCRAFT
1          C
1                DO 500 J = 1, NAC
2                   ICASFI(I,J,1) = 0
2                   IF (IH.EQ.J) GO TO 500               @ DON'T SELECT THE TCAS II M AS
2          C                                               THE VICTIM AIRCRAFT.
2                   RLAT = TJFILE(J,1)                   @ UPDATE VICTIM AIRCRAFT
2          C                                               LATITUDE (RADIANS).
2                   RLON = TJFILE(J,2)                   @ UPDATE VICTIM AIRCRAFT
2          C                                               LONGITUDE (RADIANS).
2                   ALT2=TJFILE(J,3)/6076.0              @ VICTIM AIRCRAFT
2          C                                               ALTITUDE (NMI).
2                   CALL BEAR                            @ COMPUTE R,THETA OF VICTIM
2          C                                               AIRCRAFT.
2                   BEARTX = BEARTX * 40.
2                   A = DIST                             @ HORIZONTAL DISTANCE
2          C                                               (NAUTICAL MILES).
2                   B = (ALT1 - ALT2)                    @ DIFFERENCE IN ALTITUDE
2          C                                               (NAUTICAL MILES).
```

```
***     LOAD     ***

2                 C = (SQRT(A*A + B*B))*10.             @ STRAIGHT - LINE DISTANCE
2         C                                               (SLANT RANGE).
2                 SLTRG = C + 1.                        @ IN TENTHS OF NAUTICAL MILES
2                 IF (IJFILE(J,4).EQ.0) GO TO 5004      @ IF MODE S OR TCAS II M A/C,
2         C                                               UPDATE TRACK FILE
2                 D=ABS(B*1.15*5280.)
2                 IF ((SLTRG .LE. 500) .AND. (B .LT. 1.48)) THEN
2         C                                               LOAD NEW AIRCRAFT
3                    ZERO = .FALSE.
3                    DO 1200 IX = 1, 500
4                       IF (FLD(0,10,ITRACK(I,IX)).EQ.J) GOTO 1201
4                       IF ((ITRACK(I,IX).EQ.0).AND.(.NOT.ZERO)) THEN
5                          ZERO = .TRUE.
5                          J1 = IX
5                       END IF
4          1200      CONTINUE
3                    FLD(0,10,ITRACK(I,J1)) = J
3          1201      CONTINUE
3                 ELSE                                  @ ELIMINATE FROM MODE S TRACK
3                    DO 5001 IZ = 1, 500                @ FILE ALL AIRCRAFT BEYOND 50
4                       IW = FLD(0,10,ITRACK(I,IZ))     @ NMI OF TCAS II M.
4                       IF (IW .EQ. J) ITRACK(I,IZ) = 0
4          5001      CONTINUE
3                 END IF
2          5004   CONTINUE
2         C
2         C      UPDATE TCAS ENVIRONMENTAL ARRAY
2         C
2         C       IN THE FOLLOWING PROPAGATION LOSS EQUATION:
2         C          37.80 = CONSTANT ADJUSTMENT FACTOR FOR THE UNITS
2         C          1030 = UPLINK FREQUENCY IN MEGAHERTZ
2         C          SLTRG/10 = THE SLANT RANGE IN NMI
2         C          3.0 = CABLE LOSS
2         C          60.0 = CONVERSION FROM KILOWATTS TO MILLIWATTS
2         C
2                 AP = 37.80+20.*ALOG10(1030.)+20.*ALOG10(SLTRG/10.)+3.0-60.
2                 PR = (-AP)*10.                        @ LOSSES WITHOUT ANTENNA
2         C                                               COUPLINGS.
2                 IF (SLTRG.GE.500) ICASFI(I,J,1) = 0
2                 IF (SLTRG.LT.500) THEN
3                    IF (A.LE.10.) MAXNAC = MAXNAC + 1 @ COUNT THE AIRCRAFT WITHIN
3         C                                               10 NMI OF TCAS IIM.
3                    IX = INT(SLTRG)                    @ RELATIVE RANGE.
3                    IY = INT(BEARTX)                   @ RELATIVE BEARING.
3                    IZ = INT(ABS(PR))                  @ RELATIVE POWER.
3                    FLD(00,09,ICASFI(I,J,1)) = IX      @ LOAD RANGE.
3                    FLD(17,10,ICASFI(I,J,1)) = IZ      @ LOAD POWER.
3                    FLD(34,2,ICASFI(I,J,1)) = IJFILE(J,4)
3                    TEMP1 = (IY/40.) - THETA(I)
3                    IF (TEMP1.LT.0) TEMP1 = TEMP1 + 6.28318
3                    TEMP = (TEMP1/0.098175) + 1
3                    MSEC = INT(TEMP)
3                    IF (MSEC.EQ.0) MSEC = 1
3                    FLD(27,7,ICASFI(I,J,1)) = MSEC
3                    IF (MSEC.GT.65) FLD(27,7,ICASFI(I,J,1)) = 64
3                    THE = TEMP1*40.
3                    FLD(9,8,ICASFI(I,J,1)) = INT(THE) @ LOAD BEARING OF VICTIM.
3                 END IF                                @ END VICTIM ALE FILE.
2           500   CONTINUE
```

```
***       LOAD        ***

 2        C
 2        C      COMPUTE LOCAL DENSITY ABOUT TCAS II M
 2        C
 1                  DENS(I) = MAXNAC/(3.14159*100.)          @ AIR TRAFFIC DENSITY
 1        C                                                    WITHIN 10 NAUTICAL MILES.
 1        C
 1           300 CONTINUE                                    @ END TCAS AIRCRAFT.
                 RETURN
                 END

END FTN 517 IBANK 206 DBANK 72837 COMMON
```

```
***        PRESET        ***

@FTN,S B.PRESET,PRESET
FTN 11R1     02/27/85-16:35(47,)
                   SUBROUTINE PRESET
              C
              C    THE PURPOSE OF THIS SUBROUTINE IS TO APPROXIMATE THE INTERFERENCE -
              C       LIMITING EFFECTS ON EACH TCAS AIRCRAFT.
              C       THIS SUBROUTINE IS ONLY CALLED FOR 'ITIME = 0'.
              C
              C       *************             INPUTS / OUTPUTS          ************
              C
              C    COMMON BLOCKS /     VARIABLES
              C                     INPUTS    OUTPUTS      DESCRIPTION
              C
              C         ADJSEN   /             SESIT       TCAS II M SENSITIVITIES ADJUSTED
              C                                             TO CONFORM TO I-L EQUATIONS
              C         CAS      / TJFILE                  AIRCRAFT CHARACTERISTICS FILE
              C         DPLYMT   / IDAB                    NUMBER OF MODE S AIRCRAFT
              C                    ITCA                    NUMBER OF TCAS II M AIRCRAFT
              C         ILMS     /             AMSP        TCAS II M TRANSMISSION POWER,
              C                                             ADJUSTED TO SATISFY I-L EQNS.
              C         SENS     / JSENS                   AIRCRAFT SENSITIVITY LEVELS
              C         SURV     / ITRACK                  MODE S TRACK FILE
              C         TCAA     / NUMTCA                  NUMBER OF TCAS AIRCRAFT
              C         TCDATA   / I111                    TCAS II M POINTER FILE
              C         TRAX     / JTRANS                  AIRCRAFT TRANSMISSION POWERS
              C
              C
                   INCLUDE RESTART,LIST
                   PARAMETER (NUAIR = 328)
              C
              C    THE LOGICAL VARIABLE PRINT, WHEN FALSE, WILL SUPPRESS ALL WRITE
              C    STATEMENTS IN THE MODEL.
              C
                   LOGICAL PRINT
                   DIMENSION TJFILE(NUAIR,8), IJFILE(NUAIR,8), ICASFI(83,NUAIR,1)
                   COMMON /TCDATA/ I111(83), DENS(83),
                 ?    IATIN(NUAIR), IATSU(NUAIR), IDABN(NUAIR), IDABS(NUAIR)
                   EQUIVALENCE (TJFILE,IJFILE)
                   COMMON /CAS/ ICASFI, TJFILE, NAC, II, PRINT
                   COMMON/SURV/ITRACK(83,500)
                   COMMON/TCAA/NUMTCA
                   COMMON/ILMS/KCARR(83),AMSP(83),IRESET(83)
                   COMMON/ADJSEN/SESIT(83)
                   COMMON/TRAX/JTRANS(NUAIR)
                   COMMON/SENS/JSENS(NUAIR)
                   COMMON/DPLYMT/IATCR,IDAB,ITCA
                   DEFINE FLD(I,J,K)=BITS(K,I+1,J)
                   NTRK = 500                             @ NUMBER OF TRACKS IN TRACK FILE
                   DO 1  IT = 1, NUMTCA                   @ LOOP OVER ALL TCAS IIM A/C
 1                    SQTARG = 0.
 1                    AQTARG = 0.
 1                    RCTARG = 0.
 1                    LT = I111(IT)
 1                    TCALT = TJFILE(LT,3)                @ TCAS IIM ALTITUDE.
 1                    DO 2  IF = 1, NTRK                  @ LOOP OVER TCAS IIM-MODE S
 2                       K = FLD(0,10,ITRACK(IT,IF))      @ TRACK FILE.
 2                       IF (K.EQ.0) GO TO 2              @ AIRCRAFT REMOVED FROM TRACK
 2                       ITEMP = FLD(34,2,ICASFI(IT,K,1)) @ GET ID IN ENVIROMENT ARRAY
 2                       IF (ITEMP.EQ.0) GO TO 2          @ 0 MEANS ATCRBS AIRCRAFT.
```

```
***        PRESET        ***

 2                        SR = FLD(0,9,ICASFI(IT,K,1))/10.
 2                        IF (SR.GT.35.) GO TO 2                 @ SR GREATER THAN 35 NMI
 2                        SQTARG = SQTARG + 1                    @ SQUITTER COUNT (SQTARG)
 2                        AMSALT = TJFILE(K,3)                   @ MODE S ALT. (FEET).
 2                        DALT = ABS(TCALT - AMSALT)             @ DIFFERENCE IN ALT. (FEET).
 2                        IF (SR.GT.30.) GO TO 2
 2                        IF (DALT.GT.9000.) GO TO 2
 2                        IF (SR.GT.7.16) AQTARG = AQTARG + 1 @ COUNT NUMBER IN AQUISITION
 2                        IF (SR.LE.7.16) RCTARG = RCTARG + 1 @ COUNT NUMBER IN ROLL CALL
 2             2     CONTINUE                                    @ END TRACK LOOP.
 1                   IMDS = IDAB + ITCA                          @ TOTAL NUMBER OF MODE S
 1          C                                                      AND TCAS IIM AIRCRAFT.
 1                   NTCS=SQTARG*(FLOAT(ITCA))/(FLOAT(IMDS))@ TOTAL NUMBER OF SQUITTER
 1          C                                                      TARGETS FOR MODE S / TCAS.
 1          C
 1          C     DETERMINE NUMBER OF POWER & SENSITIVITY ADJUSTMENTS NEEDED TO SATISFY
 1          C     INEQUALITY #1 OF INTERFERENCE-LIMITING.  MAKE NO MORE THAN SEVEN
 1          C     ADJUSTMENTS.  SEE ECAC-PR-84-003 AND THE TCAS MOPS FOR MORE INFORMATION.
 1          C
 1                   JATEN = -1
 1                   ANEQ = 300.
 1          C
 1            1200   IF ((ANEQ .GE. 280.) .AND. (JATEN .LE. 7)) THEN
 2                        JATEN = JATEN + 1
 2          C
 2          C  APPROXIMATE THE NUMBER OF INTERROGATIONS SENT BY TCAS IIM.
 2                        NHT=((1.2*RCTARG)+(0.05*AQTARG*(0.890**JATEN)))
 2          C
 2          C  CALCULATE INEQUALITY #1 AND CHECK TO SEE IF IT HAS BEEN SATISFIED.
 2                        ANEQ = NHT*(.892**JATEN)*NTCS
 2                        GO TO 1200
 2                   END IF
 1                   SESIT(IT) = JSENS(LT) + JATEN           @ ADJUSTED TCAS IIM SENSITIVITY
 1          C                                                  TO BE USED IN I-L.
 1                   ATRANS=JTRANS(LT)/1000.
 1                   AMSP(IT)=(ATRANS*(0.790**JATEN))      @ ADJUSTED TCAS IIM POWER
 1          C                                                TO BE USED IN I-L.
 1              1 CONTINUE
                  RETURN
                  END

END FTN 236 IBANK 88 DBANK 73821 COMMON
```

```
***        RANN        ***

@FTN,S B.RANN,RANN
FTN 11R1      02/27/85-16:35(4,)
                    SUBROUTINE RANN(RAN)
              C
              C     THIS SUBROUTINE IS A RANDOM NUMBER GENERATOR DEVELOPED BY C. W. EHLER.
              C
                    LOGICAL GTIST
                    IF (.NOT.(GTIST)) THEN
 1                     ISEED = 532413
 1                     GTIST = .TRUE.
 1                  END IF
                    ISEED = ISEED*3125
                    RAN = ABS(FLOAT(ISEED))*.2910383048299172500-10
                    RETURN
                    END

END FTN 39 IBANK 16 DBANK
```

```
***      STATS      ***

@FTN,S B.STATS,STATS
FTN 11R1    02/27/85-16:35(49,)
          SUBROUTINE STATS
     C
     C    THE PURPOSE OF THIS SUBROUTINE IS TO COMPUTE STATISTICS FOR SEVERAL
     C       TCAS VARIABLES.
     C
     C    ************************** INPUTS / OUTPUTS ******************************
     C
     C    COMMON BLOCKS /    VARIABLES
     C                    INPUTS   OUTPUTS    DESCRIPTIONS
     C
     C            ATE    / DRATE    DRATE      TOTAL INTERROGATIONS REC'D BY TCAS IIM
     C            CAS    / NAC                 NUMBER OF AIRCRAFT IN DEPLOYMENT
     C            DPLYMT / IATCR               NUMBER OF ATCRBS AIRCRAFT
     C                     IDAB                NUMBER OF MODE S AIRCRAFT
     C                     ITCA                NUMBER OF TCAS II M AIRCRAFT
     C            SMOOTH / NOW                 NUMBER OF TCAS IIM INTERROGATIONS
     C            TCDATA / IATIN               ATCRBS INTERROGATIONS DUE TO TCAS II M
     C                     IATSU               ATCRBS SUPPRESSIONS DUE TO TCAS II M
     C                     IDABN               MODE S INTERROGATIONS DUE TO TCAS II M
     C                     IDABS               MODE S SUPPRESSIONS DUE TO TCAS II M
     C            TCRAT1 / ATCRAT              TCAS I INTERROGATIONS AT EACH AIRCRAFT
     C            TEMP   / ITIME               SIMULATION TIME
     C
     C
          INCLUDE RESTART,LIST
          PARAMETER (NUAIR = 328)
     C
     C    THE LOGICAL VARIABLE PRINT, WHEN FALSE, WILL SUPPRESS ALL WRITE
     C    STATEMENTS IN THE MODEL.
     C
          LOGICAL PRINT
          DIMENSION TJFILE(NUAIR,8), IJFILE(NUAIR,8), ICASFI(83,NUAIR,1)
          COMMON /TCDATA/ I111(83), DENS(83),
         ?   IATIN(NUAIR), IATSU(NUAIR), IDABN(NUAIR), IDABS(NUAIR)
          EQUIVALENCE (TJFILE,IJFILE)
          COMMON /CAS/ ICASFI, TJFILE, NAC, II, PRINT
          COMMON/TEMP/ITIME
          COMMON/SMOOTH/NOW(83),TIS(83),TPS(83)
          COMMON/ATE/DRATE(83)
          COMMON/DPLYMT/IATCR,IDAB,ITCA
          COMMON/TCRAT1/ATCRAT(NUAIR)
     C
     C    COMPUTE AVERAGE NUMBER OF TCAS II M WITHIN EACH TCAS VOLUME, AND
     C       AVERAGE NUMBER OF INTERROGATIONS SENT BY TCAS II M.
     C
          SIGSUM = 0.0
          PSUM = 0.0
          DSUM = 0.0
          DO 10  NS = 1, ITCA
 1           ANOW = NOW(NS)                        @ TCAS IIM SQUITTER COUNTER.
 1           PSUM = PSUM + ANOW/FLOAT(ITCA)        @ COMPUTE AVERAGE NUMBER OF
 1           SIGSUM = SIGSUM + ANOW*ANOW           @ TCAS IIM IN VOLUME.
 1           DRATE(NS) = DRATE(NS) + 1
 1           DSUM = DSUM + DRATE(NS)/FLOAT(ITCA)   @ AVERAGE INTERROGATIONS
 1     10 CONTINUE
          ESDEV = SQRT((SIGSUM/FLOAT(ITCA)) - PSUM*PSUM)
     C
```

```
***       STATS       ***

                SUM = ITCA + IDAB                         @ TOTAL NUMBER OF MODE S A/C
                SUM1 = IATCR                              @ NUMBER OF ATCRBS-ONLY A/C
                ISUM2 = 0
                ISUM3 = 0
                ISUM4 = 0
                ISUM5 = 0
                ISUM8 = 0
                ISUM9 = 0
                ISUM10 = 0
                ISUM11 = 0
                DO 11  IK = 1, NAC
1                  IF (IJFILE(IK,4).NE.0) THEN
1         C
1         C        COMPUTE STATS ON TCAS I, TCAS IIM, AND MODE S INTERROGATIONS.
1         C
2                     ISUM2 = ISUM2 + IDABN(IK) + ATCRAT(IK)
2                     ISUM3 = ISUM3 + IDABS(IK)
2                     ISUM4 = ISUM4 + (IDABN(IK) + ATCRAT(IK))**2.
2                     ISUM5 = ISUM5 + IDABS(IK)*IDABS(IK)
2                  ELSE
2         C
2         C        COMPUTE NUMBER OF WHISPER-SHOUT INTERROGATIONS AND SUPPRESSIONS
2         C        RECEIVED AT ATCRBS.
2         C
2                     ISUM8 = ISUM8 + IATIN(IK)+ATCRAT(IK) @ W-S INTERROGATION RECEIVED
2         C                                                 AT ATCRBS DUE TO TCAS I & II
2                     ISUM9 = ISUM9 + IATSU(IK)            @ WHISPER-SHOUT SUPPRESSION
2         C                                                 RECEIVED AT ATCRBS.
2                     ISUM10 = ISUM10 + (IATIN(IK) + ATCRAT(IK))**2.
2                     ISUM11 = ISUM11 + IATSU(IK)*IATSU(IK)
2                  END IF
1            11 CONTINUE
                AI = ISUM8/SUM1                           @ ATCRBS INTERROGATION.
                AS = ISUM9/SUM1                           @ ATCRBS SUPPRESSION.
                AISDV = SQRT(ISUM10/SUM1 - AI*AI)         @ STANDARD DEVIATION
                ASSDV = SQRT(ISUM11/SUM1 - AS*AS)
                DI = ISUM2/SUM                            @ AVERAGE MODE S INTERROGATIONS
                DS = ISUM3/SUM                            @ AVERAGE MODE S SUPPRESSIONS
                DISDV = SQRT(ISUM4/SUM - DI*DI )          @ STANDARD DEVIATION
                DSSDV = SQRT(ISUM5/SUM - DS*DS)
                IF (PRINT) WRITE(*,12) ITIME, PSUM, ESDEV, DSUM, AI, AISDV, AS
                IF (PRINT) WRITE(*,13) ASSDV, DI, DISDV, DS, DSSDV
             12 FORMAT ('1',1X,'SIMULATION TIME:  ',I3,' SECONDS',/,/,1X,
               ?   'AVERAGE NUMBER OF TCAS II M IN ANY TCAS II M VOLUME:  ',
               ?   F10.4,/,1X,
               ?   '    STANDARD DEVIATION:                                ',
               ?   F10.4,/,/,1X,
               ?   'AVERAGE NUMBER OF INTERROGATIONS SENT BY TCAS II M:  ',
               ?   F10.4,/,/,1X,
               ?   'AVERAGE ATCRBS INTERRROGATIONS RECEIVED DUE TO TCAS II M:  ',
               ?   F10.4,/,1X,
               ?   '    STANDARD DEVIATION:                                ',
               ?   F10.4,/,/,1X,
               ?   'AVERAGE ATCRBS SUPPRESSIONS RECEIVED DUE TO TCAS II M:  ',
               ?   F10.4)
             13 FORMAT (/,1X,
               ?   '    STANDARD DEVIATION:                                ',
               ?   F10.4,/,/,1X,
               ?   'AVERAGE MODE S INTERROGATIONS RECEIVED DUE TO TCAS II M:  ',
```

```
***       STATS       ***

          ?   F10.4,/,1X,
          ? ' '    STANDARD DEVIATION:                                              ',
          ?   F10.4,/,/,1X,
          ?   'AVERAGE MODE S SUPPRESSIONS RECEIVED DUE TO TCAS II M:   ',
          ?   F10.4,/,1X,
          ?   '    STANDARD DEVIATION:                                              ',
          ?   F10.4)
              RETURN
              END

END FTN 297 IBANK 309 DBANK 31993 COMMON
```

```
***       TCAS1       ***

@FTN,S 8.TCAS1,TCAS1
FTN 11R1     02/27/85-16:35(19,)
                SUBROUTINE TCAS1
          C
          C     THE FUNCTION OF THIS SUBROUTINE IS TO DETERMINE THE EFFECTS OF
          C        DEPLOYING TCAS1 AIRCRAFT IN THE ENVIRONMENT.  ALL MODE S AIRCRAFT
          C        ARE ASSUMED TO BE TCAS I-EQUIPPED.  THIS SUBROUTINE IS CALLED ONLY
          C        WHEN A TCAS I ANALYSIS IS CONDUCTED.
          C
          C
          C    *****************  INPUTS / OUTPUTS  **************************************
          C
          C    COMMON BLOCKS /    VARIABLES
          C                     INPUTS   OUTPUTS    DESCRIPTION
          C
          C          ANTO    / PASBOT              RECEIVING ANTENNA PATTERNS:  BOTTOM
          C                    PASTOP                                           TOP
          C          ANTT    / ANTBOT              TRANSMITTING ANTENNA PATTERNS: BOTTOM
          C                  / ANTTOP                                           TOP
          C          CAS     / IJFILE              AIRCRAFT TYPES
          C                    NAC                 NUMBER OF AIRCRAFT
          C                    TJFILE              AIRCRAFT CHARACTERISTICS
          C          SENS    / JSENS               SENSITIVITY LEVELS FOR EACH AIRCRAFT
          C          TCRAT1 /           ATCRAT     NUMBER OF TCAS I INTERROGATIONS AT EACH
          C                                           AIRCRAFT
          C
          C
                INCLUDE RESTART,LIST
                PARAMETER (NUAIR = 328)
          C
          C     THE LOGICAL VARIABLE PRINT, WHEN FALSE, WILL SUPPRESS ALL WRITE
          C     STATEMENTS IN THE MODEL.
          C
                LOGICAL PRINT
                DIMENSION TJFILE(NUAIR,8), IJFILE(NUAIR,8), ICASFI(83,NUAIR,1)
                COMMON /TCDATA/ I111(83), DENS(83),
               ?   IATIN(NUAIR), IATSU(NUAIR), IDABN(NUAIR), IDABS(NUAIR)
                EQUIVALENCE (TJFILE,IJFILE)
                COMMON /CAS/ ICASFI, TJFILE, NAC, II, PRINT
                COMMON/ANTT/ANTTOP(19),ANTBOT(19)
                COMMON/ANTO/PASTOP(19),PASBOT(19)
                COMMON/SENS/JSENS(NUAIR)
                COMMON/BBBEAR/TLAT,TLON,RLAT,RLON,DIST,BEARTX
                COMMON/TCRAT1/ATCRAT(NUAIR)
                DO 10  NN = 1, NAC                        @ SELECT A TCAS I AIRCRAFT.
   1               IF ((IJFILE(NN,4).EQ.3).OR.(IJFILE(NN,4).EQ.0)) GO TO 10
   1               TLAT = TJFILE(NN,1)                    @ TCAS I LATITUDE (RADIANS)
   1               TLON = TJFILE(NN,2)                    @ TCAS I LONGITUDE (RADIANS)
   1               ALT1A = TJFILE(NN,3)/6076.0            @ TCAS I ALTITUDE (MILES)
   1               ITYP = IJFILE(NN,4)
   1               DO 11  IA = 1, NAC                     @ PICK VICTIM A/C
   2                  IF (NN.EQ.IA) GO TO 11
   2                  RLAT = TJFILE(IA,1)                 @ VICTIM LATITUDE (RADIANS)
   2                  RLON = TJFILE(IA,2)                 @ VICTIM LONGITUDE (RADIANS)
   2                  ALT2A = TJFILE(IA,3)/6076.0         @ VICTIM ALTITUDE (MILES)
   2                  CALL BEAR                           @ GET HORIZONTAL DISTANCE
   2      C                                                 BETWEEN AIRCRAFT
   2                  BC = (ALT1A - ALT2A)                @ VERTICAL SEPARATION (NMI)
   2                  CO = (SQRT(DIST*DIST + BC*BC))      @ SLANT RANGE (NMI)
```

```
***        TCAS1        ***

 2                       ARGA=(BC/DIST)
 2                       THET = (ATAN(ARGA))*57.296          @ DETERMINE ANGLE BETWEEN
 2                       THETA1 = ABS((THET+90.)/10.)        @ TCAS I AND VICTIM A/C
 2                       ITH1 = THETA1 + 1
 2                       THETA2 = ABS((THET-90.)/10.)
 2                       ITH2 = THETA2 + 1
 2           C
 2           C     DETERMINE GAIN OF ANTENNA.
 2           C
 2                       GN1 = ANTTOP(ITH1) + ((THETA1 + 1) - FLOAT(ITH1))*
 2                1           (ANTTOP(ITH1+1) - ANTTOP(ITH1))
 2                       GN2 = PASBOT(ITH2) + ((THETA2 + 1) - FLOAT(ITH2))*
 2                1           (PASBOT(ITH2+1) - PASBOT(ITH2))
 2                       GN3 = ANTBOT(ITH1) + ((THETA1 + 1) - FLOAT(ITH1))*
 2                1           (ANTBOT(ITH1+1) - ANTBOT(ITH1))
 2                       GN4 = PASTOP(ITH2) + ((THETA2 + 1) - FLOAT(ITH2))*
 2                1           (PASTOP(ITH2+1) - PASTOP(ITH2))
 2                       GS = GN1
 2                       GV = GN2
 2                       IF ((GN4.GT.GN2).AND.(IJFILE(IA,4).NE.0)) GV = GN4
 2                       GNCOUP = GS + GV
 2                       LOS = 36.58 + 20.*ALOG10(1030.)+20.*ALOG10(CD*1.15)+3.-60
 2                       PR = -13.98 - LOS + GNCOUP - 3.     @ COMPUTE RECEIVED POWER
 2                       IF (PR.LT.JSENS(IA)) GO TO 11       @ IF POWER RECEIVED LESS THAN
 2           C                                                 SENSITIVITY, DO NOT COUNT
 2                       ATCRAT(IA) = ATCRAT(IA) + 1         @ COUNTER ARRAY AT VICTIMS DUE
 2           C                                                 TO TCAS I INTERROGATIONS.
 2              11    CONTINUE
 1              10 CONTINUE
                   RETURN
                   END

END FTN 274 IBANK 87 DBANK 32067 COMMON
```

```
***        TCSMOT        ***

@FTN,S A.TCSMOT,A.TCSMOT
FTN 11R11R1A 05/30/85-13:16(27,)
          SUBROUTINE TCSMOT
      C
      C
      C     THE PURPOSE THIS SUBROUTINE IS TO PRODUCE VALUES FOR THE
      C    EMISSION POWERS AND INTERROGATIONS RATES SMOOTHED OVER A 16-SECOND
      C    TIME PERIOD.
      C
      C    **************  INPUTS / OUTPUTS  ********************************
      C
      C    COMMON BLOCKS /   VARIABLES
      C                      INPUTS  OUTPUTS     DESCRIPTIONS
      C
      C          ATE     / DRATE                TOTAL INTERROGATIONS REC'D BY EACH
      C                                               TCAS II M TRANSPONDER
      C          CAS     / II                   TCAS II M IDENTITY
      C          ILMS    / AMSP                 ADJUSTED TCAS II M TRANSMISSION POWER
      C          SMOOTH /            TIS        SMOOTHED EMISSION POWER
      C                              AVMSPW     SMOOTHED TOTAL MODE S POWER
      C          TCDATA / I111                  TCAS II M POINTER FILE
      C          TEMP    / ITIME                ELAPSED TIME IN SIMULATION
      C
      C
          INCLUDE RESTART,LIST
          PARAMETER (NUAIR = 743)
      C
      C   THE LOGICAL VARIABLE PRINT, WHEN FALSE, WILL SUPPRESS ALL WRITE
      C   STATEMENTS IN THE MODEL.
      C
          LOGICAL POISMO,PINTLI,PTCSMT,PATMOD,PDISIN,PFILES,PFRUIT,PSTATS
          COMMON /PRTBL/ POISMO,PINTLI,PTCSMT,PATMOD,PDISIN,PFILES,PFRUIT,
         2  PSTATS
      *
          DIMENSION TJFILE(NUAIR,8), IJFILE(NUAIR,8), ICASFI(83,NUAIR,1)
          COMMON /TCDATA/ I111(83), DENS(83),
         ?   IATIN(NUAIR), IATSU(NUAIR), IDABN(NUAIR), IDABS(NUAIR)
          EQUIVALENCE (TJFILE,IJFILE)
          COMMON /CAS/ ICASFI, TJFILE, NAC, II, PRINT
          INCLUDE ATE,LIST
            COMMON /ATE/ DRATE(83)
          INCLUDE TEMP,LIST
            COMMON /TEMP/ ITIME
          INCLUDE SMOOTH,LIST
            COMMON /SMOOTH/ NOW(83), AVMSPW(83),TIS(83)
          INCLUDE ILMS,LIST
            COMMON /ILMS/ NWSL(83), AMSP(83), IRESET(83), ATSUMP(0:83),
         2    IRETRN, TPOW
          INCLUDE TRAX,LIST
      *
            COMMON /TRAX/ JTRANS(NUAIR)
          REAL INSTNT(0:15,83),RSUMP(83)
      *
          INDX = MOD(ITIME, 16)          @ POINTER TO CURRENT STORAGE TIME: 0 - 15
          TMSPW = DRATE(II) * AMSP(II)  @ TOTAL MODE S  POWER IN CURRENT SECOND
      *
          IF(ITIME .LE. 15)THEN          @ DON'T SMOOTH FOR 1ST 15 SECONDS
             AVMSPW(II) = TMSPW
             TIS(II) = DRATE(II)
```

```
***       TCSHOT       ***

 1          ELSE
 1             AVTIME = ITIME - 15         @ AVERAGING TIME
 1             RSUMP(II) = RSUMP(II) + TMSPW - INSTNT(INDX,II)
 1             AVMSPW(II) = RSUMP(II)/AVTIME
 1             TIS(II) = TIS(II) + ( ORATE(II) - TIS(II) )/AVTIME
 1             INSTNT(INDX,II) = TMSPW
 1          END IF
            RETURN
            END

END FTN 115 IBANK 1447 DBANK 72173 COMMON

@HDG,P  ***       TRANSP      ***
```

```
***       TRANSP       ***

@FTN,S B.TRANSP,TRANSP
FTN 11R1      02/27/85-16:35(13,)
                SUBROUTINE TRANSP
          C
          C        SET POWER AND SENSITIVITY CHARACTERISTICS DERIVED FROM ATC-9 FOR EACH
          C     TYPE OF TRANSPONDER.
          C
          C        **************     INPUTS / OUTPUTS              **************
          C     COMMON BLOCKS /     VARIABLES
          C                      INPUTS     OUTPUTS       DESCRIPTION
          C
          C          CAS      / IJFILE                    TYPE OF EACH AIRCRAFT
          C                     NAC                       NUMBER OF AIRCRAFT
          C          SENS     /             JSENS         SENSITIVITY LEVEL OF EACH A/C
          C          TRAX     /             JTRANS        TRANSMISSION POWER OF EACH A/C
          C
          C
                INCLUDE RESTART,LIST
                PARAMETER (NUAIR = 328)
          C
          C     THE LOGICAL VARIABLE PRINT, WHEN FALSE, WILL SUPPRESS ALL WRITE
          C     STATEMENTS IN THE MODEL.
          C
                LOGICAL PRINT
                DIMENSION TJFILE(NUAIR,8), IJFILE(NUAIR,8), ICASFI(83,NUAIR,1)
                COMMON /TCDATA/ I111(83), DENS(83),
               ?  IATIN(NUAIR), IATSU(NUAIR), IDABN(NUAIR), IDABS(NUAIR)
                EQUIVALENCE (TJFILE,IJFILE)
                COMMON /CAS/ ICASFI, TJFILE, NAC, II, PRINT
                COMMON/TRAX/JTRANS(NUAIR)
                COMMON/SENS/JSENS(NUAIR)
                DIMENSION XNORM(NUAIR)
                DIMENSION YNORM(NUAIR)
                DIMENSION XSENS(NUAIR)
                DIMENSION YSENS(NUAIR)
          C
          C     TRANSMISSION POWER
          C
                XNORM(1) = 16 398 535
                YNORM(1) = 16 398 535
                CALL RANDN(XNORM,NUAIR,27.0, 1.5)           @ MODE S POWER--NOMINAL
          C                                                 IS 27; STANDARD
          C                                                 DEVIATION IS 1.5.
                CALL RANDN (YNORM, NUAIR, 29.2, 0.5)        @ TCAS POWER--NOMINAL IS
          C                                                 29.2, STANDARD
          C                                                 DEVIATION IS 0.5.
                DO  17  IQ = 1, NAC
1                   IF (IJFILE(IQ,4) .EQ. 0) THEN           @ DETERMINE ATCRBS
2                         CALL RANN(RAN)                    @ TRANSMISSION POWER
2                         RAN = RAN * 100.                  @ USING PROBABILITY
2                               IF (RAN .LE. 0.2) THEN      @ DISTRIBUTION FROM ATC-9
3                                     DIFF = 11.
3                               ELSE IF (RAN .LE. 0.4) THEN
3                                     DIFF = 10.
3                               ELSE IF (RAN .LE. 1.27) THEN
3                                     DIFF = 9.
3                               ELSE IF (RAN .LE. 1.92) THEN
3                                     DIFF = 8.
3                               ELSE IF (RAN .LE. 3.00) THEN
```

```
***      TRANSP      ***

3                    DIFF = 7.
3                ELSE IF (RAN .LE. 5.60) THEN
3                    DIFF = 6.
3                ELSE IF (RAN .LE. 9.50) THEN
3                    DIFF = 5.
3                ELSE IF (RAN .LE. 15.60) THEN
3                    DIFF = 4.
3                ELSE IF (RAN .LE. 25.40) THEN
3                    DIFF = 3.
3                ELSE IF (RAN .LE. 36.90) THEN
3                    DIFF = 2.
3                ELSE IF (RAN .LE. 49.00) THEN
3                    DIFF = 1.
3                ELSE IF (RAN .LE. 60.50) THEN
3                    DIFF = 0.
3                ELSE IF (RAN .LE. 74.40) THEN
3                    DIFF = -1.
3                ELSE IF (RAN .LE. 81.80) THEN
3                    DIFF = -2.
3                ELSE IF (RAN .LE. 90.70) THEN
3                    DIFF = -3.
3                ELSE IF (RAN .LE. 95.70) THEN
3                    DIFF = -4.
3                ELSE IF (RAN .LE. 98.30) THEN
3                    DIFF = -5.
3                ELSE IF (RAN .LE. 99.38) THEN
3                    DIFF = -6.
3                ELSE IF (RAN .LE. 99.78) THEN
3                    DIFF = -7.
3                ELSE
3                    DIFF = -8.
3                END IF
2            JTRANS(IQ) = 500 000 * (0.7943 ** DIFF)
2        ELSE IF (IJFILE(IQ,4) .EQ. 1)  THEN              @ DETERMINE MODE S
2            XCONVT = XNORM(IQ)/10.                       @ TRANSMISSION POWER
2            XNORM(IQ) = (10. ** XCONVT) * 1 000.
2            JTRANS(IQ) = XNORM(IQ)
2        ELSE                                             @ DETERMINE TCAS II M
2            YCONVT = YNORM(IQ) / 10.                     @ TRANSMISSION POWER
2            YNORM(IQ) = (10. ** YCONVT) * 1 000.
2            JTRANS(IQ) = YNORM(IQ)
2        END IF
1   17 CONTINUE
1     C
1     C    SENSITIVITY CALCULATIONS
1     C
           XSENS(1) = 16 398 540
           YSENS(1) = 16 398 540
           CALL RANON (XSENS, NUAIR, 77.60, 1.5)          @ MODE S SENSITIVITY--
      C                                                     NOMINAL: 77.60
      C                                                     STANDARD DEVIATION: 1.5
           CALL RANON (YSENS, NUAIR, 77.50, 0.75)         @ TCAS II M SENSITIVITY--
      C                                                     NOMINAL: 77.50
      C                                                     STAN. DEVIATION: 0.75
           DO 12   IZ = 1, NAC
1              IF (IJFILE(IZ,4) .EQ. 0) THEN              @ DETERMINE ATCRBS
2                  CALL RANN (RAN)                        @ SENSITIVITY
2                  RAN = RAN * 100.
2                  IF (RAN .LE. 0.2) THEN
```

```
***        TRANSP        ***

3                    SENT = 48.
3                ELSE IF (RAN .LE. 0.4) THEN
3                    SENT = 51.
3                ELSE IF (RAN .LE. 0.6) THEN
3                    SENT = 52.
3                ELSE IF (RAN .LE. 1.0) THEN
3                    SENT = 53.
3                ELSE IF (RAN .LE. 1.43) THEN
3                    SENT = 54.
3                ELSE IF (RAN .LE. 2.07) THEN
3                    SENT = 55.
3                ELSE IF (RAN .LE. 2.28) THEN
3                    SENT = 56.
3                ELSE IF (RAN .LE. 3.79) THEN
3                    SENT = 57.
3                ELSE IF (RAN .LE. 4.00) THEN
3                    SENT = 58.
3                ELSE IF (RAN .LE. 4.43) THEN
3                    SENT = 59.
3                ELSE IF (RAN .LE. 5.29) THEN
3                    SENT = 60.
3                ELSE IF (RAN .LE. 6.80) THEN
3                    SENT = 61.
3                ELSE IF (RAN .LE. 8.52) THEN
3                    SENT = 62.
3                ELSE IF (RAN .LE. 10.89) THEN
3                    SENT = 63.
3                ELSE IF (RAN .LE. 14.12) THEN
3                    SENT = 64.
3                ELSE IF (RAN .LE. 17.14) THEN
3                    SENT = 65.
3                ELSE IF (RAN .LE. 19.94) THEN
3                    SENT = 66.
3                ELSE IF (RAN .LE. 25.33) THEN
3                    SENT = 67.
3                ELSE IF (RAN .LE. 31.80) THEN
3                    SENT = 68.
3                ELSE IF (RAN .LE. 39.14) THEN
3                    SENT = 69.
3                ELSE IF (RAN .LE. 44.10) THEN
3                    SENT = 70.
3                ELSE IF (RAN .LE. 51.22) THEN
3                    SENT = 71.
3                ELSE IF (RAN .LE. 57.26) THEN
3                    SENT = 72.
3                ELSE IF (RAN .LE. 65.03) THEN
3                    SENT = 73.
3                ELSE IF (RAN .LE. 69.78) THEN
3                    SENT = 74.
3                ELSE IF (RAN .LE. 75.17) THEN
3                    SENT = 75.
3                ELSE IF (RAN .LE. 81.00) THEN
3                    SENT = 76.
3                ELSE IF (RAN .LE. 86.61) THEN
3                    SENT = 77.
3                ELSE IF (RAN .LE. 90.06) THEN
3                    SENT = 78.
3                ELSE IF (RAN .LE. 94.59) THEN
3                    SENT = 79.
```

```
***       TRANSP       ***
 3                         ELSE IF (RAN .LE. 95.58) THEN
 3                              SENT = 80.
 3                         ELSE IF (RAN .LE. 98.03) THEN
 3                              SENT = 81.
 3                         ELSE IF (RAN .LE. 98.46) THEN
 3                              SENT = 82.
 3                         ELSE IF (RAN .LE. 98.89) THEN
 3                              SENT = 83.
 3                         ELSE IF (RAN .LE. 99.32) THEN
 3                              SENT = 84.
 3                         ELSE
 3                              SENT = 87.
 3                         END IF
 2                         SENT = SENT + 3.
 2                         JSENS(IZ) = -SENT
 2                    ELSE IF (IJFILE(IZ,4) .EQ. 1) THEN              @ DETERMINE MODE S
 2                         ZSENS = -XSENS(IZ)                         @ SENSITIVITY
 2                         IF (ZSENS .LT. -80.)ZSENS = -80.
 2                         IF (ZSENS .GT. -74.)ZSENS = -74.
 2                         JSENS(IZ) = ZSENS
 2                    ELSE                                            @ DETERMINE TCAS
 2                         ZSENS = -YSENS(IZ)                         @ SENSITIVITY
 2                         IF (ZSENS .LT. -79.) ZSENS = -79.
 2                         IF (ZSENS .GT. -75.) ZSENS = -75.
 2                         JSENS(IZ) = ZSENS
 2                    END IF
 1             12 CONTINUE
                  RETURN
                  END

END FTN 547 IBANK 1508 DBANK 31985 COMMON
```

```
***      TSQUIT      ***

@FTN,S A.TSQUIT,A.TSQUIT
FTN 11R11R1A 05/30/85-13:16(41,)
              SUBROUTINE TSQUIT( IPRGTS )
       C
       C         THE PURPOSE OF THIS SUBROUTINE IS TO COUNT THE NUMBER OF TCAS II-M
       C      DETECTED BY SQUITTERS AND SET THE SQUITTER START TIME.
       C
       C      ****************************   INPUTS / OUTPUTS   **********************
       C
       C      COMMON BLOCKS /     VARIABLES
       C                        INPUTS   OUTPUTS    DESCRIPTION
       C
       C           ARG LIST / IPRGTS               INDICATES WHETHER THE REC POW > SENSITI
       C             CAS    / II                   TCAS II M IDENTITY
       C             SINT   / K                    VICTIM AIRCRAFT IDENTITY
       C             SMOOTH /          NOW         NUMBER OF TCAS II M DETECTED
       C             TCAA   / NUMTCA               NUMBER OF TCAS II M AIRCRAFT
       C             TCDATA / I111                 TCAS II M POINTER FILE
       C             TEMP   / ITIME                ELAPSED TIME IN SIMULATION
       C             TPREPL / PREP                 PROBABILITY OF REPLY FOR EACH AIRCRAFT
       C             TRAN   / ITLAST   ITLAST      TCAS II M SQUITTER START TIME
       C             TRAN   / IACTOT               CONVERTS A/C ID TO TCAS ID (II)
       C
              INCLUDE RESTART,LIST
              PARAMETER (NUAIR = 743)
       C
       C      THE LOGICAL VARIABLE PRINT, WHEN FALSE, WILL SUPPRESS ALL WRITE
       C      STATEMENTS IN THE MODEL.
       C
              LOGICAL PDISMD,PINTLI,PTCSMT,PATMOD,PDISIN,PFILES,PFRUIT,PSTATS
              COMMON /PRTBL/ PDISMD,PINTLI,PTCSMT,PATMOD,PDISIN,PFILES,PFRUIT,
             2  PSTATS
       *
              DIMENSION TJFILE(NUAIR,8), IJFILE(NUAIR,8), ICASFI(83,NUAIR,1)
              COMMON /TCDATA/ I111(83), DENS(83),
             ?   IATIN(NUAIR), IATSU(NUAIR), IDABN(NUAIR), IDABS(NUAIR)
              EQUIVALENCE (TJFILE,IJFILE)
              COMMON /CAS/ ICASFI, TJFILE, NAC, II, PRINT
              INCLUDE TCAA,LIST
                COMMON /TCAA/ NUMTCA
              INCLUDE TEMP,LIST
                COMMON /TEMP/ ITIME
              INCLUDE TRAN,LIST
                COMMON /TRAN/ ITLAST(83,83),IACTOT(NUAIR)
              INCLUDE SMOOTH,LIST
                COMMON /SMOOTH/ NOW(83), AVMSPW(83),TIS(83)
              INCLUDE SINT,LIST
                COMMON /SINT/ LPLUS, K, ITOB(100)
              INCLUDE TPREPL,LIST
                COMMON /TPREPL/ PREP(NUAIR)
              DEFINE FLD(I,J,K) = BITS(K,I+1,J)
       C
       C            COMPUTE NUMBER OF TCAS II M DETECTED BY SQUITTER
       C
       **
       *          K IS THE ID OF THE N'TH TCAS A/C. IT IS NECESSARY TO FIND THE VALUE
       *          OF N, WHICH IS USED AS AN INDEX OF THE TCST AND ITLAST ARRAYS.
       *
              IDTCAS = IACTOT(K)
```

```
***       TSQUIT       ***

          *
               IF( IDTCAS .GT. NUMTCA) WRITE(6,16)(ITC,I111(ITC),
             2   IACTOT(I111(ITC)),ITC=1,NUMTCA)
      16       FORMAT(' TSQUIT:II I111 IACTOT',5(I6,'-',I3,'-',I3) )
          *
               ITLSQ = FLD(1,10,ITLAST(II,IDTCAS) )
               IF( ITLSQ .EQ. 0) ITLSQ = NINT( RANDOM() * 9.) + 1
          *
               IDELT = ITIME - ITLSQ
               INTRK = FLD(0,1,ITLAST(II,IDTCAS) )  @ IS THE K' A/C IN SQUITTER FILE
          *
          * AT TIME = 1 SEC, LOAD ALL TCAS A/C THAT CAN BE DETECTED BY THEIR SQUITTER
          * AND HAVE A SUFFICIENTLY HIGH PROP OF DETECTING THE SQUITTER
          *
               IF( ITIME .EQ. 1)THEN                        @ AT TIME=1, LOAD SQUITTER FILE
 1               CALL RANN(RAN)
 1               IF( IPRGTS .EQ. 1 .AND. PREP(K) .GT. RAN)THEN    @ SQUITTER RECEIVED
 2                  IF(INTRK .EQ. 0) NOW(II) = NOW(II) + 1         @ NEW A/C IN SQIT FILE
 2                  FLD(0,1,ITLAST(II,IDTCAS) ) = 1                @ ADD K'TH A/C TO SQ F
 2               END IF
 2        *
 2        * AT TIMES > I SEC, CHECK TO SEE IF A TCAS A/C SHOULD BE ADDED OR DELETED FROM
 2        * THE SQUITTER FILE
 2        *
 1             ELSE IF( IDELT .GT. 20 .AND. INTRK .EQ. 1)THEN  @ > 20 SEC SINCE LAST RX S
 1                NOW(II) = NOW(II) - 1               @ 1 LESS A/C IN SQUITTER FILE
 1                FLD(0,1,ITLAST(II,IDTCAS) ) = 0   @ DELETE K'TH A/C FROM SQUIT FILE
 1             ELSE IF( MOD(IDELT,10) .EQ. 0)THEN   @ K'TH TCAS TX TIME
 1               CALL RANN(RAN)
 1               IF( IPRGTS .EQ. 1 .AND. PREP(K) .GT. RAN)THEN    @ SQUITTER RECEIVED
 2                  IF(INTRK .EQ. 0) NOW(II) = NOW(II) + 1        @ NEW A/C IN SQIT FILE
 2                  FLD(0,1,ITLAST(II,IDTCAS) ) = 1               @ ADD K'TH A/C TO SQ F
 2                  FLD(1,10,ITLAST(II,IDTCAS) ) = ITIME          @ LASTEST SQ RX TIME
 2               END IF
 1             END IF
 1        *
 1        C    WRITE(6,16)IPRGTS,II,IDTCAS,ITLSQ,IDELT,LSQUIT,NOW(II)
 1        *
               RETURN
               END

END FTN 222 IBANK 98 DBANK 79490 COMMON

@HDG,P  ***       TSTART       ***
```

```
***        TSTART        ***

@FTN,S A.TSTART,A.TSTART
FTN 11R11R1A 05/30/85-13:16(23,)
                  SUBROUTINE TSTART
          C
          C       THIS SUBROUTINE COUNTS THE NUMBER OF TCAS II M AIRCRAFT, SETS UP A
          C          POINTER FILE TO THEIR LOCATION IN THE GENERAL AIRCRAFT CHARACTERISTICS
          C          FILE, AND SETS THE SQUITTER PHASE FOR EACH TCAS II M AIRCRAFT.
          C
          C       **************          INPUTS / OUTPUTS            *********************
          C
          C       COMMON BLOCKS /    VARIABLES
          C                         INPUTS   OUTPUTS        DESCRIPTION
          C
          C             CAS      / IJFILE                   TYPE OF EACH AIRCRAFT
          C                         NAC                     NUMBER OF AIRCRAFT
          C             TCAA     /           NUMTCA         NUMBER OF TCAS II M AIRCRAFT
          C             TCDATA   /           I111           TCAS II M POINTER FILE
          C             TRAN     /           TCST           SQUITTER PHASE START TIME
          C
          C
                  INCLUDE RESTART,LIST
                  PARAMETER (NUAIR = 743)
          C
          C       THE LOGICAL VARIABLE PRINT, WHEN FALSE, WILL SUPPRESS ALL WRITE
          C       STATEMENTS IN THE MODEL.
          C
                  LOGICAL PDISMD,PINTLI,PTCSMT,PATMOD,PDISIN,PFILES,PFRUIT,PSTATS
                  COMMON /PRTBL/ PDISMD,PINTLI,PTCSMT,PATMOD,PDISIN,PFILES,PFRUIT,
                 2  PSTATS
          *
                  DIMENSION TJFILE(NUAIR,8), IJFILE(NUAIR,8), ICASFI(83,NUAIR,1)
                  COMMON /TCDATA/ I111(83), DENS(83),
                 1   IATIN(NUAIR), IATSU(NUAIR), IDABN(NUAIR), IDABS(NUAIR)
                  EQUIVALENCE (TJFILE,IJFILE)
                  COMMON /CAS/ ICASFI, TJFILE, NAC, II, PRINT
                  INCLUDE TCAA,LIST
                    COMMON /TCAA/ NUMTCA
                  INCLUDE TRAN,LIST
                    COMMON /TRAN/ ITLAST(83,83),IACTOT(NUAIR)
                  DEFINE  FLD(I,J,K) = BITS(K,I+1,J)
                  DO 300  I = 1, NAC                          @ COMPUTE NUMBER OF TCAS IIM
  1                  IF (IJFILE(I,4).NE.3) GO TO 300
  1                  NUMTCA = NUMTCA + 1                      @ COUNT TCAS IIM A/C
  1                  I111(NUMTCA) = I                         @ SET UP POINTER TO LOCATION OF
  1                  IACTOT(I) = NUMTCA                       @ TCAS IIM IN A/C CHAR. FILE
  1       C
  1           300 CONTINUE
                  RETURN
                  END

END FTN 57 IBANK 25 DBANK 78395 COMMON

@HDG,P  ***      WSPOWE      ***
```

```
***       WSPOWE       ***

@FTN,S B.WSPOWE,WSPOWE
FTN 11R1       02/27/85-16:36(23,)
                     SUBROUTINE WSPOWE
              C
              C      THE PURPOSE OF THIS SUBROUTINE IS TO LOAD INTO ARRAYS THE POWER
              C          ASSOCIATED FOR EACH LEVEL OF WHISPER SHOUT FOR THE TOP AND
              C          BOTTOM ANTENNA.
              C
              C          *************          INPUTS / OUTPUTS          *************
              C
              C      COMMON BLOCKS /    VARIABLES
              C                        INPUT       OUTPUT      DESCRIPTION
              C
              C         WSHOUT     /               IPOWB       W-S LEVELS FOR TOP BACK ANTENNA
              C                                    IPOWBO      W-S LEVELS FOR BOTTOM ANTENNA
              C                                    IPOWF       W-S LEVELS FOR TOP FRONT ANTENNA
              C                                    IPOWS       W-S LEVELS FOR SIDE ANTENNAS
              C
              C      EACH WHISPER SHOUT STEP CHECKED FOR TOTAL RADIATED POWER
              C         OF TCAS IIM-ATCRBS EMMISSIONS.
              C
                     COMMON/WSHOUT/IPRF(24),IPRS(40),IPRB(15),IPRBOT(4),IPOWF(24),
                    ?IPOWS(41),IPOWB(15),IPOWBO(4)
              C
              C      LOAD POWER FOR EACH WHISPER SHOUT LEVEL.
              C
                     IDROP = 0
                     IPEAK = 49
                     DO 3002  K = 1, 24                          @ TCAS IIM TOP-FRONT ANTENNA
1                       IPOWF(K) = IPEAK - IDROP*1               @ (24 LEVELS)
1                       IDROP = IDROP + 1                        @ POWER LEVELS RANGE FROM
1                       FACT = (IPOWF(K) - 30.)/10.              @ 49 DBM TO 26 DBM
1                       POWFR = POWFR + (10.**FACT)
1               3002 CONTINUE
                     IDROP = 0
                     IPEAK = 45
                     DO 3003  K = 1, 40, 2                       @ TCAS IIM LEFT & RIGHT SIDE
1                       IPOWS(K) = IPEAK - IDROP*1               @ 20 LEVELS PER SIDE
1                       IPOWS(K+1) = IPOWS(K)                    @ POWER LEVELS RANGE FROM
1                       IDROP = IDROP + 1                        @ 45 TO 26 DBM
1                       FACT = (IPOWS(K) - 30.)/10.
1                       POWSD = POWSD + (10.**FACT)
1               3003 CONTINUE
                     IDROP = 0
                     IPEAK = 40
                     DO 3004  K = 1, 15                          @ TCAS IIM BACK (15 LEVELS)
1                       IPOWB(K) = IPEAK - IDROP*1               @ POWER LEVELS RANGE FROM
1                       IDROP = IDROP + 1                        @ 40 TO 26 DBM
1                       FACT = (IPOWB(K) - 30.)/10.
1                       POWBK = POWBK + (10.**FACT)
1               3004 CONTINUE
                     IDROP = 0
                     IPEAK = 36
                     DO 3005  K = 1, 4                           @ TCAS IIM BOTTOM (4 LEVELS)
1                       IPOWBO(K) = IPEAK - IDROP*2.             @ POWER LEVELS RANGE FROM
1                       IDROP = IDROP + 1                        @ 36 TO 30 DBM
1                       FACT = (IPCWBO(K) - 30.)/10.
1                       POWBOT = POWBOT + (10.**FACT)
1               3005 CONTINUE
```

```
***        WSPOWE        ***

 1      58.   C
 1      59.   C      CALCULATE TOTAL ATCRBS INTERROGATION CONTRIBUTION FOR TOP & BOTTOM
 1      60.   C         ANTENNAS.
 1      61.   C
        62.          PTOT = POWFR + POWSD + POWBK + POWBOT
        63.          RETURN
        64.          END

END FTN 176 IBANK 45 DBANK 167 COMMON
```

APPENDIX C

SAMPLE EXECUTION

The control cards that execute the TCAS SEM follow. Each record begins in column 1 and is spaced as shown.

```
@RUN,/RTP (JRID),(CHARGE#),(USER),30,1000
@ASG,AX FAA*TCAS/U.
@ASG,A FAA*INRATE/U.
@USE 8.,FAA*INRATE/U.
@ASG,A FAA*OUTRTS/U.
@USE 10.,FAA*OUTRTS/U.
@ASG,A FAA*BASIN1/U.
@XQT FAA*TCAS/U.RUN.
@ADD FAA*BASIN1/U.
@FIN
@@
```

The files named in the above records are defined in TABLE C-1. The output file to be used in the DABS/ATCRBS/AIMS PPM contains the information shown in TABLE C-2.

TABLE C-1

FILES USED IN THE TCAS SEM

File Name	Description
INRATE	Input file of Interrogation and Suppression Rates at each aircraft due to ground ATC from DABS/ATCRBS/AIMS PPM
OUTRTS	TCAS Signal Rates to be used in the DABS/ATCRBS/AIMS PPM
BASIN1	Deployment Information: latitude, longitude, altitude, type, and velocity of each aircraft

TABLE C-2

KEY TO COLUMNS OF TCAS SEM OUTPUT

Column	Description
Aircraft Identity	Index ID of aircraft in the deployment file
Mode S Misaddresses	Number of Mode S misaddressed interrogations received above sensitivity
Mode S Suppressions	Number of ATCRBS suppressions received above sensitivity at Mode S transponder-equipped aircraft
Modes S Interrogations	Number of ATCRBS interrogations received above sensitivity at Mode S transponder-equipped aircraft
ATCRBS Suppressions	Number of ATCRBS interrogations received above sensitivity at ATCRBS transponder-equipped aircraft
ATCRBS Interrogations	Number of ATCRBS interrogations received above sensitivity at ATCRBS transponder-equipped aircraft
TCAS II M Deadtime	Mutual-suppression time (in μs) of each TCAS II M receiver
TCAS I Interrogations	Number of TCAS I interrogations received above sensitivity at ATCRBS and Mode S-equipped aircraft

TCAS SEM OUTPUT

AIRCRAFT IDENTITY S	MODE S MISADDRESSES	MODE S ADDRESSES	MODE S SUPPRESSIONS	MODE S INTERROGATIONS	ATCRBS SUPPRESSIONS	ATCRBS INTERROGATIONS	TCAS II M DEAD TIME	TCAS I INTERROGATION
1	63	.00000	0	0	0	5	.000	.000
2	135	5.00000	57	33	0	0	5180.000	.000
3	471	6.00000	102	67	0	0	.000	.000
4	12	.00000	0	0	0	0	.000	.000
5	179	.00000	0	0	30	36	.000	.000
6	279	.00000	0	0	79	56	.000	.000
7	421	.00000	0	0	218	76	.000	.000
8	77	.00000	0	0	2	16	.000	.000
9	325	.00000	0	0	160	67	.000	.000
10	127	5.00000	51	26	0	0	5280.000	.000
11	0	.00000	0	0	0	0	.000	.000
12	139	.00000	0	0	9	14	.000	.000
13	43	.00000	0	0	18	18	.000	.000
14	852	.00000	0	0	976	245	.000	.000
15	676	.00000	0	0	413	120	.000	.000
16	315	.00000	0	0	78	59	.000	.000
17	0	.00000	0	0	0	0	.000	.000
18	190	.00000	0	0	33	35	.000	.000
19	289	.00000	0	0	78	55	.000	.000
20	312	.00000	0	0	51	59	.000	.000
21	51	.00000	0	0	14	9	.000	.000
22	163	1.00000	20	20	0	0	.000	.000
23	724	.00000	0	0	227	129	.000	.000
24	88	.00000	0	0	4	13	.000	.000
25	815	.00000	0	0	477	151	.000	.000
26	43	1.00000	2	4	0	0	.000	.000

27	327	1.00000	76	59	0	0	.000	.000
28	146	.00000	0	0	11	14	.000	.000
29	284	3.00000	42	33	0	0	.000	.000
30	126	.00000	0	0	8	24	.000	.000
31	13	.00000	0	0	1	5	.000	.000
32	473	1.00000	101	60	0	0	.000	.000
33	171	.00000	0	0	27	33	.000	.000
34	743	.00000	0	0	174	124	.000	.000
35	530	.00000	0	0	92	91	.000	.000
36	15	1.00000	0	2	0	0	5450.000	.000
37	4	.00000	0	0	3	2	.000	.000
38	97	.00000	0	0	14	18	.000	.000
39	30	4.00000	33	17	0	0	5450.000	.000
40	721	.00000	0	0	218	135	.000	.000
41	85	2.00000	42	29	0	0	.000	.000
42	81	.00000	0	0	34	34	.000	.000
43	336	.00000	0	0	51	53	.000	.000
44	49	3.00000	31	17	0	0	.000	.000
45	765	.00000	0	0	411	197	.000	.000
46	12	.00000	0	0	0	5	.000	.000
47	115	.00000	0	0	30	39	.000	.000
48	220	.00000	0	0	136	50	.000	.000
49	125	3.00000	90	40	0	5	.000	.000
50	17	.00000	0	0	0	2	.000	.000
51	121	3.00000	55	36	0	0	.000	.000
52	103	.00000	0	0	69	38	.000	.000
53	13	.00000	0	0	9	10	.000	.000
54	9	.00000	0	0	0	2	.000	.000
55	12	.00000	0	0	0	0	.000	.000
56	38	2.00000	30	14	0	0	.000	.000

57	15	.00000	0	0	1	2	.000	.000
58	18	.00000	0	0	42	11	.000	.000
59	19	2.00000	29	10	0	0	5480.000	.000
60	22	.00000	0	0	15	5	.000	.000
61	202	.00000	0	0	47	53	.000	.000
62	63	1.00000	31	23	0	0	5630.000	.000
63	41	2.00000	42	23	0	0	.000	.000
64	414	.00000	0	0	113	32	.000	.000
65	6	.00000	0	0	0	0	.000	.000
66	22	.00000	0	0	10	5	.000	.000
67	6	.00000	0	0	0	2	.000	.000
68	129	6.00000	49	33	0	0	.000	.000
69	305	1.00000	25	53	0	0	.000	.000
70	158	.00000	0	0	52	25	.000	.000
71	118	1.00000	34	28	0	0	.000	.000
72	336	.00000	0	0	58	62	.000	.000
73	14	.00000	0	0	3	3	.000	.000
74	575	8.00000	245	93	0	0	5660.000	.000
75	10	.00000	0	0	0	0	.000	.000
76	130	1.00000	46	30	0	0	5480.000	.000
77	376	.00000	0	0	75	63	.000	.000
78	185	1.00000	34	31	0	0	.000	.000
79	101	.00000	0	0	18	29	.000	.000
80	574	.00000	0	0	148	117	.000	.000
81	322	.00000	0	0	39	65	.000	.000
82	4	.00000	0	0	0	2	.000	.000
83	394	.00000	0	0	79	77	.000	.000
84	93	.00000	0	0	11	17	.000	.000
85	173	6.00000	107	41	0	0	5480.000	.000

86	110	.00000	0	0	16	27	.000	.000
87	0	.00000	0	0	0	0	.000	.000
88	135	.00000	0	0	18	27	.000	.000
89	27	.00000	0	0	1	6	.000	.000
90	14	.00000	0	0	0	1	.000	.000
91	570	2.00000	223	90	0	0	.000	.000
92	103	.00000	0	0	24	25	.000	.000
93	678	.00000	0	0	157	117	.000	.000
94	256	4.00000	49	36	0	0	.000	.000
95	222	4.00000	44	24	0	0	.000	.000
96	0	.00000	0	0	1	2	.000	.000
97	272	.00000	0	0	70	56	.000	.000
98	157	.00000	0	0	13	23	.000	.000
99	89	.00000	0	0	11	15	.000	.000
100	4	.00000	0	0	3	2	.000	.000
101	40	.00000	0	0	7	10	.000	.000
102	6	.00000	0	0	0	0	.000	.000
103	176	.00000	0	0	20	22	.000	.000
104	284	.00000	0	0	71	65	.000	.000
105	178	.00000	0	0	22	21	.000	.000
106	273	2.00000	81	42	0	0	.000	.000
107	336	.00000	0	0	67	56	.000	.000
108	44	.00000	0	0	2	8	.000	.000
109	10	.00000	0	0	0	1	.000	.000
110	202	.00000	0	0	92	55	.000	.000
111	0	.00000	0	0	0	0	.000	.000
112	34	.00000	0	0	11	9	.000	.000
113	28	1.00000	5	5	0	0	.000	.000
114	74	1.00000	32	18	0	0	.000	.000
115	64	.00000	0	0	18	14	.000	.000

116	94	.00000	0	0	30	24	.000	.000
117	196	.00000	0	0	27	28	.000	.000
118	210	.00000	0	0	64	59	.000	.000
119	86	.00000	0	0	13	22	.000	.000
120	509	4.00000	174	85	0	0	.000	.000
121	450	.00000	0	0	141	110	.000	.000
122	194	2.00000	151	61	0	0	.000	.000
123	150	.00000	0	0	22	23	.000	.000
124	645	.00000	0	0	434	131	.000	.000
125	393	6.00000	127	76	0	0	.000	.000
126	321	.00000	0	0	231	116	.000	.000
127	138	2.00000	149	35	0	0	.000	.000
128	169	4.00000	119	38	0	0	5450.000	.000
129	224	3.00000	133	72	0	0	.000	.000
130	409	6.00000	118	80	0	0	.000	.000
131	123	.00000	0	0	27	20	.000	.000
132	0	.00000	0	0	0	2	.000	.000
133	193	.00000	0	0	49	29	.000	.000
134	187	.00000	0	0	26	32	.000	.000
135	158	8.00000	26	27	0	0	.000	.000
136	273	.00000	0	0	101	75	.000	.000
137	226	.00000	0	0	53	35	.000	.000
138	255	.00000	0	0	42	44	.000	.000
139	676	.00000	0	0	299	148	.000	.000
140	0	.00000	0	0	0	0	.000	.000
141	63	.00000	0	0	10	13	.000	.000
142	76	.00000	0	0	14	10	.000	.000
143	30	.00000	0	0	0	0	.000	.000
144	71	.00000	0	0	12	15	.000	.000

145	136	.00000	0	0	32	22	.000	.000
146	625	.00000	0	0	312	140	.000	.000
147	48	.00000	0	0	13	12	.000	.000
148	497	.00000	0	0	189	115	.000	.000
149	191	.00000	0	0	53	30	.000	.000
150	280	.00000	0	0	47	44	.000	.000
151	152	.00000	0	0	29	32	.000	.000
152	495	11.00000	227	75	0	0	6780.000	.000
153	24	.00000	0	0	0	0	.000	.000
154	612	.00000	0	0	295	152	.000	.000
155	230	.00000	0	0	75	50	.000	.000
156	118	10.00000	135	50	0	0	5050.000	.000
157	30	.00000	0	0	10	7	.000	.000
158	119	.00000	0	0	14	23	.000	.000
159	264	1.00000	79	38	0	0	.000	.000
160	132	3.00000	105	46	0	0	6080.000	.000
161	91	.00000	0	0	12	9	.000	.000
162	363	.00000	0	0	180	66	.000	.000
163	468	.00000	0	0	307	129	.000	.000
164	407	2.00000	233	87	0	0	.000	.000
165	34	.00000	0	0	56	11	.000	.000
166	164	.00000	0	0	43	39	.000	.000
167	70	.00000	0	0	15	8	.000	.000
168	8	.00000	0	0	0	0	.000	.000
169	224	9.00000	192	58	0	0	8580.000	.000
170	167	.00000	0	0	119	50	.000	.000
171	233	.00000	0	0	40	33	.000	.000
172	642	.00000	0	0	301	150	.000	.000
173	266	.00000	0	0	87	62	.000	.000
174	320	12.00000	250	87	0	0	5080.000	.000

175	139	.00000	0	0	10	14	.000	.000
176	150	.00000	0	0	54	33	.000	.000
177	139	.00000	0	0	76	40	.000	.000
178	146	6.00000	67	32	0	0	5780.000	.000
179	82	.00000	0	0	19	9	.000	.000
180	139	.00000	0	0	51	31	.000	.000
181	60	.00000	0	0	14	9	.000	.000
182	69	.00000	0	0	21	24	.000	.000
183	273	.00000	0	0	120	77	.000	.000
184	212	.00000	0	0	163	75	.000	.000
185	272	.00000	0	0	115	70	.000	.000
186	181	.00000	0	0	116	63	.000	.000
187	141	.00000	0	0	20	26	.000	.000
188	308	.00000	0	0	72	51	.000	.000
189	218	.00000	0	0	68	68	.000	.000
190	425	.00000	0	0	174	104	.000	.000
191	30	.00000	0	0	16	9	.000	.000
192	65	1.00000	10	10	0	0	.000	.000
193	170	5.00000	60	40	0	0	61[illegible].000	.000
194	270	.00000	0	0	103	81	.000	.000
195	26	.00000	0	0	8	5	.000	.000
196	524	6.00000	207	85	0	0	.000	.000
197	153	4.00000	65	33	0	0	.000	.000
198	193	4.00000	82	39	0	0	.000	.000
199	142	.00000	0	0	38	26	.000	.000
200	60	.00000	0	0	45	29	.000	.000
201	18	.00000	0	0	0	1	.000	.000
202	412	.00000	0	0	172	81	.000	.000
203	245	7.00000	84	49	0	0	6680.000	.000

204	30	.00000	0	0	10	9	.000	.000
205	57	1.00000	8	11	0	0	5050.000	.000
206	181	.00000	0	0	77	45	.000	.000
207	483	.00000	0	0	174	89	.000	.000
208	191	.00000	0	0	20	29	.000	.000
209	65	.00000	0	0	17	20	.000	.000
210	823	.00000	0	0	970	249	.000	.000
211	420	4.00000	215	76	0	0	7200.000	.000
212	184	.00000	0	0	98	42	.000	.000
213	153	3.00000	101	56	0	0	.000	.000
214	69	.00000	0	0	54	26	.000	.000
215	153	.00000	0	0	34	32	.000	.000
216	225	3.00000	53	31	0	0	.000	.000
217	243	.00000	0	0	46	39	.000	.000
218	157	.00000	0	0	51	53	.000	.000
219	391	6.00000	236	74	0	0	.000	.000
220	65	.00000	0	0	34	23	.000	.000
221	57	.00000	0	0	15	11	.000	.000
222	78	.00000	0	0	22	11	.000	.000
223	301	12.00000	201	60	0	0	.000	.000
224	690	.00000	0	0	365	133	.000	.000
225	10	.00000	0	0	0	0	.000	.000
226	95	.00000	0	0	57	40	.000	.000
227	224	.00000	0	0	50	38	.000	.000
228	65	.00000	0	0	20	11	.000	.000
229	264	.00000	0	0	76	62	.000	.000
230	142	.00000	0	0	51	44	.000	.000
231	57	1.00000	25	11	0	0	.000	.000
232	243	4.00000	97	66	0	0	.000	.000
233	105	.00000	0	0	3	5	.000	.000

234	12	.00000	0	0	1	3	.000	.000
235	22	.00000	0	0	17	6	.000	.000
236	710	.00000	0	0	356	151	.000	.000
237	167	.00000	0	0	45	42	.000	.000
238	54	.00000	0	0	3	6	.000	.000
239	257	.00000	0	0	83	52	.000	.000
240	537	.00000	0	0	264	149	.000	.000
241	8	.00000	0	0	0	0	.000	.000
242	514	.00000	0	0	173	119	.000	.000
243	56	.00000	0	0	71	16	.000	.000
244	193	.00000	0	0	21	34	.000	.000
245	57	.00000	0	0	6	9	.000	.000
246	130	.00000	0	0	23	22	.000	.000
247	285	.00000	0	0	153	84	.000	.000
248	69	2.00000	49	20	0	0	.000	.000
249	33	.00000	0	0	4	8	.000	.000
250	779	.00000	0	0	411	161	.000	.000
251	69	.00000	0	0	86	30	.000	.000
252	167	.00000	0	0	119	61	.000	.000
253	225	7.00000	61	39	0	0	.000	.000
254	95	.00000	0	0	103	43	.000	.000
255	153	4.00000	120	54	0	0	.000	.000
256	65	.00000	0	0	47	23	.000	.000
257	762	.00000	0	0	442	148	.000	.000
258	320	.00000	0	0	149	108	.000	.000
259	780	.00000	0	0	562	174	.000	.000
260	54	.00000	0	0	8	7	.000	.000
261	61	.00000	0	0	96	13	.000	.000
262	69	4.00000	95	26	0	0	.000	.000

263	70	2.00000	69	26	0	0	5580.000	.000
264	59	5.00000	36	20	0	0	6080.000	.000
265	441	.00000	0	0	119	109	.000	.000
266	252	.00000	0	0	75	53	.000	.000
267	35	.00000	0	0	0	1	.000	.000
268	203	.00000	0	0	123	71	.000	.000
269	111	.00000	0	0	11	5	.000	.000
270	210	4.00000	156	64	0	0	.000	.000
271	0	.00000	0	0	0	0	.000	.000
272	120	.00000	0	0	24	19	.000	.000
273	105	.00000	0	0	7	9	.000	.000
274	61	.00000	0	0	21	12	.000	.000
275	445	10.00000	244	79	0	0	7620.000	.000
276	103	3.00000	39	23	0	0	.000	.000
277	65	.00000	0	0	13	15	.000	.000
278	785	.00000	0	0	485	191	.000	.000
279	89	1.00000	23	28	0	0	6490.000	.000
280	168	.00000	0	0	41	33	.000	.000
281	65	.00000	0	0	44	12	.000	.000
282	133	.00000	0	0	58	31	.000	.000
283	156	.00000	0	0	60	56	.000	.000
284	167	.00000	0	0	43	38	.000	.000
285	246	.00000	0	0	28	56	.000	.000
286	142	.00000	0	0	28	35	.000	.000
287	179	4.00000	47	35	0	0	.000	.000
288	326	.00000	0	0	93	39	.000	.000
289	57	.00000	0	0	13	7	.000	.000
290	130	2.00000	59	34	0	0	.000	.000
291	266	.00000	0	0	112	93	.000	.000
292	130	.00000	0	0	15	19	.000	.000

293	135	.00000	0	0	5	11	.000	.000
294	35	.00000	0	0	0	0	.000	.000
295	143	.00000	0	0	11	25	.000	.000
296	111	.00000	0	0	31	10	.000	.000
297	500	.00000	0	0	144	116	.000	.000
298	417	8.00000	199	88	0	0	.000	.000
299	517	4.00000	353	94	0	0	.000	.000
300	133	.00000	0	0	9	23	.000	.000
301	154	.00000	0	0	20	20	.000	.000
302	362	9.00000	203	73	0	0	.000	.000
303	96	5.00000	91	42	0	0	5050.000	.000
304	503	3.00000	327	99	0	0	.000	.000
305	749	.00000	0	0	1014	268	.000	.000
306	96	.00000	0	0	17	16	.000	.000
307	467	.00000	0	0	181	103	.000	.000
308	0	.00000	0	0	0	0	.000	.000
309	317	.00000	0	0	73	55	.000	.000
310	308	.00000	0	0	94	57	.000	.000
311	505	.00000	0	0	249	110	.000	.000
312	270	.00000	0	0	52	54	.000	.000
313	83	.00000	0	0	3	6	.000	.000
314	329	.00000	0	0	75	99	.000	.000
315	489	.00000	0	0	161	87	.000	.000
316	262	.00000	0	0	73	68	.000	.000
317	723	.00000	0	0	419	142	.000	.000
318	15	.00000	0	0	0	1	.000	.000
319	396	.00000	0	0	139	72	.000	.000
320	210	.00000	0	0	75	36	.000	.000
321	201	.00000	0	0	86	47	.000	.000

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